JUNE, 1958
Vol. 12, No. 6

FT food technology

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THE TECHNICAL ARTICLES IN BRIEF

Evaluation technique *Peroxidase activity*

Application of peroxidase test paper in food processing. Herman J. Morris.

The value of a test paper for measuring the peroxidase activity of blanched vegetables has been appraised. Results given by the test paper are compared with results of the Masure and Campbell qualitative and quantitative methods. The test papers offer food processors a convenient means of evaluating peroxidase activity of food samples. (See page 265)

Storage test *Frozen canned bread*

Moisture migration in frozen canned bread. J. G. Woodroof and H. R. Malcom.

To minimize the problems of moisture migration in frozen canned bread held for more than 9 months, it is recommended that (a) the position of the cans of frozen bread be changed every 6 months, (b) the bread be removed from the cans before thawing, and (c) a satisfactory means of moistening and heating be provided for redistribution of moisture in the bread. (See page 268)

Drying technique *Microwave sublimation*

Microwave sublimation of foods. David A. Copson.

Operating conditions for microwave sublimation of foods have been examined. Electrical loss factor differences between water and ice indicate that for the all ice system an orderly process for addition of sublimation energy to ice occurs. The interaction of the energy with the ice when dried food is also present indicates a selective heating of the ice portion which contributes intrinsic control in the drying process. As a consequence of the loss factor for ice, penetration of the energy in depth is much greater than in the case of water so that adequate heating is provided within the ice phase. Reduction in drying cycles by 75% over the conventional heating time was demonstrated. Energy required by the sublimation process was accounted for by the factors for increased microwave energy effects with larger loads and with ice. Sublimation rates were shown to be directly related to the microwave energy supplied. (See page 270)

Color measurement *Baby Foods*

Colorimetry of baby foods. Gideon E. Livingston, Bertram Gersten, and Joseph Shore.

Several commonly used tools for the measurement of color in fruit and vegetable baby food purées are evaluated. Values obtained from the various instruments were submitted to analysis of variance. It appears that different observers observe different results on the same product, depending upon the instrument used. Any instrument, however, can be used effectively to compare data obtained at a given time with data obtained some time before. (See page 273)

Processing *Solid pack canned foods*

Studies in canning processes. II. The effects of the variation with temperature of the thermal properties of foods. H. L. Evans.

Solid pack canned foods contain between 70% and 90% water. Their normal properties are therefore largely determined by those of water. The thermal conductivity and heat capacity of water are known to vary considerably with temperature. A discussion is given of the effects such variations have on heating and cooling curves. The slope and lag factor of the cooling curve are found to be different from those of the heating curve. Other factors affecting slopes and lag factors are also considered. (See page 276)

Fermentation *Cucumbers*

Lindane residue changes during fermentation and processing of pickles. Melvin R. Johnston.

Lindane spray residue carrythrough during the fermentation of cucumbers and the processing of pickles was investigated. Residues resulting from spraying harvested cucumbers and from field application of insect control schedules were evaluated. Amount of lindane was determined on the raw cucumbers, cured salt stock, and the resulting sour, sweet and dill pickles. The Schechter-Hornstein colorimetric method for lindane was used. Pickling cucumbers were found to contain 10 to 11 p.p.m. of lindane when sprayed (after harvest) with one pound of 25% lindane per 100 gallons of water, which was reduced to 2 to 4 p.p.m. in the pickles. Insect control schedules with 7 and 11 applications prior to harvest resulted in a lindane residue of about one p.p.m. on the cucumbers; the pickles contained less than 0.5 p.p.m. When lindane was added to the fermentation vats, at the rate of 10 p.p.m. (brine and cucumbers) the salt stock contained 7.3 p.p.m.; whereas an equal amount of inositol and lindane (10 p.p.m.) resulted in 4.25 p.p.m. in the salt stock and the pickles contained 7 and 3 p.p.m., respectively. (See page 281)

JUNE COVER. The cover cuts celebrate the pineapple industry. The pineapple, as has been said, is neither a pine nor an apple. It is, however, a succulent and fragrant product that technology and science have made available in various forms—whole, canned, frozen—not to mention its availability as a natural flavor for ice creams, preserves, liqueurs, etc.

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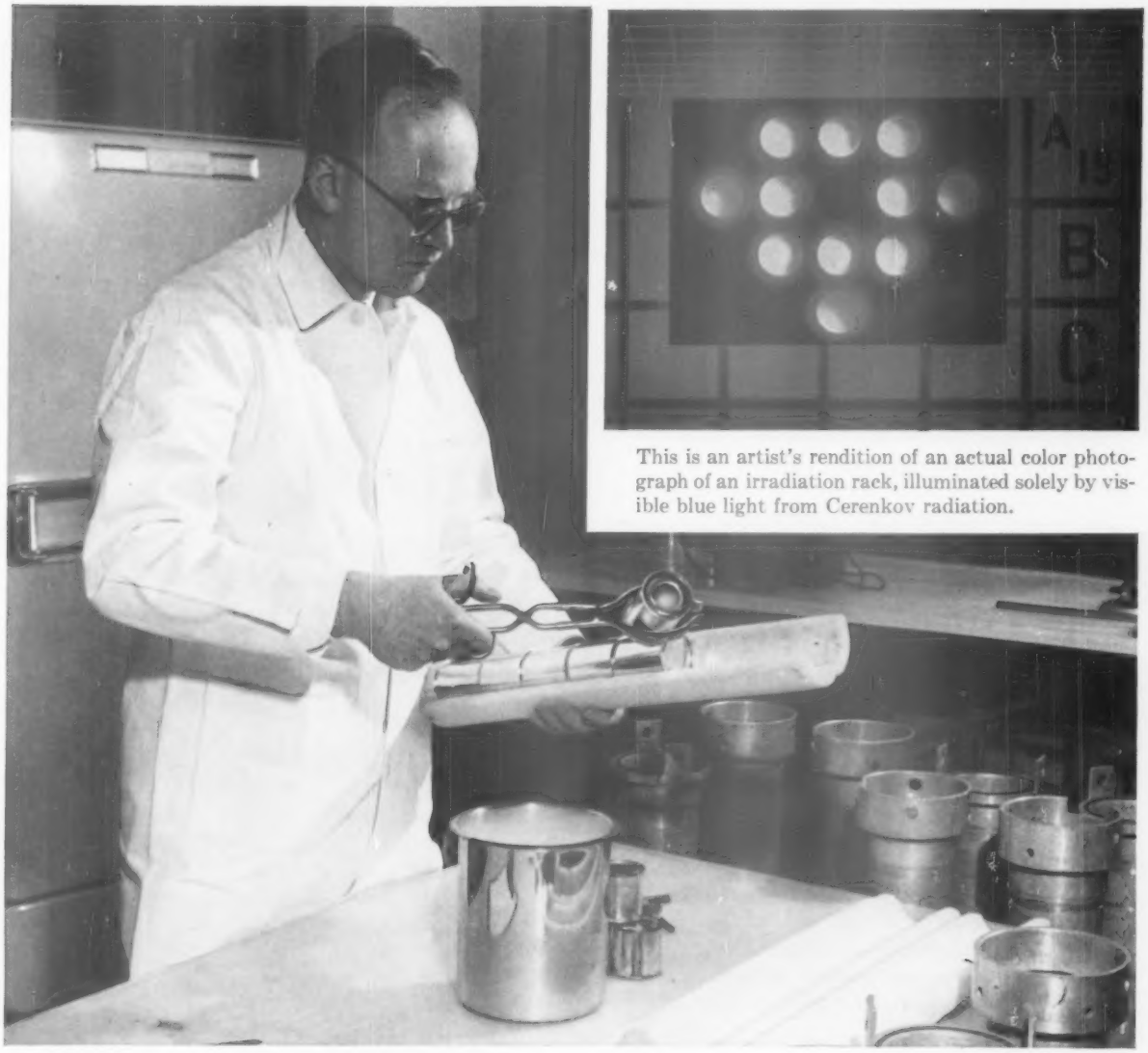

This is an artist's rendition of an actual color photograph of an irradiation rack, illuminated solely by visible blue light from Cerenkov radiation.

One experiment calls for the exposure of frozen canned foods to gamma irradiation. This photo, taken at the Argonne National Laboratory, shows cans being placed in an insulating cylinder. The cylinder will be sealed within one of the aluminum urns (at right), then lowered into the water of the radiation canal. There it is exposed to rays yielding from one to two million roentgens an hour.

High energy irradiation, alone or combined with thermal processing or freezing, shows interesting possibilities as a means for preserving packaged foods. To explore fully this new technique, American Can Company scientists are participating in an extensive irradiation research program.

Part of this work is carried on through cooperative projects at government and university laboratories, part through independent studies at Canco's multi-million-dollar Research Center in Barrington, Ill. As a result of this program, food for the nation's dinner tables some day may be sterilized by nuclear energy.

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Consumer preference — *Canned pears*

Factors influencing consumer opinion of canned Bartlett pears. Rose Marie Pangborn and Sherman J. Leonard.

Bartlett pears differing in total acidity were canned with sugar syrups of 30°, 40°, 50°, 60°, or 70° Brix, then evaluated by 378 families in Shasta County, California. Using a hedonic scale of 7 descriptive terms and single sample presentation, consumers found a soluble solids-acid ratio of between 138 and 171 as most acceptable. Fruit with high acidity (approx. 0.160% citric) was liked best with a sugar content of 22.8° Brix whereas pears with low acidity (approx. 0.135% citric) were liked equally well at 18.5° and 22.6° Brix levels. Participants under 16 and over 50 years of age tended to prefer the sweeter pears as well as to assign higher scores to all the samples. Consumers who tasted pears in the evening assigned higher scores than noon or morning tasters. Also, higher values were given to the fruit by the more frequent consumers of the product. Reproducible results were obtained from the re-testing of 100 families after a period of 6 months.

Flavor was the most frequently mentioned attribute of the experimental pack as well as the reason most often given for purchase. Data showed the consumers' positive association between sweetness and pear flavor. Texture and color were apparently unaffected by the sugar levels employed. (See page 284)

Quality tests — *Wheat, wheat products*

Objective tests of quality in wheat and wheat products. M. A. Barmore.

A discussion of wheat quality problems made from the point of view of the chemist associated with wheat breeding. Methods of measuring milling factors that affect quality, mixing characteristics of flour, measures of flour quality, baking performance, the protein variable are among the topics reviewed. (See page 291)

Quality retention — *Shrimp*

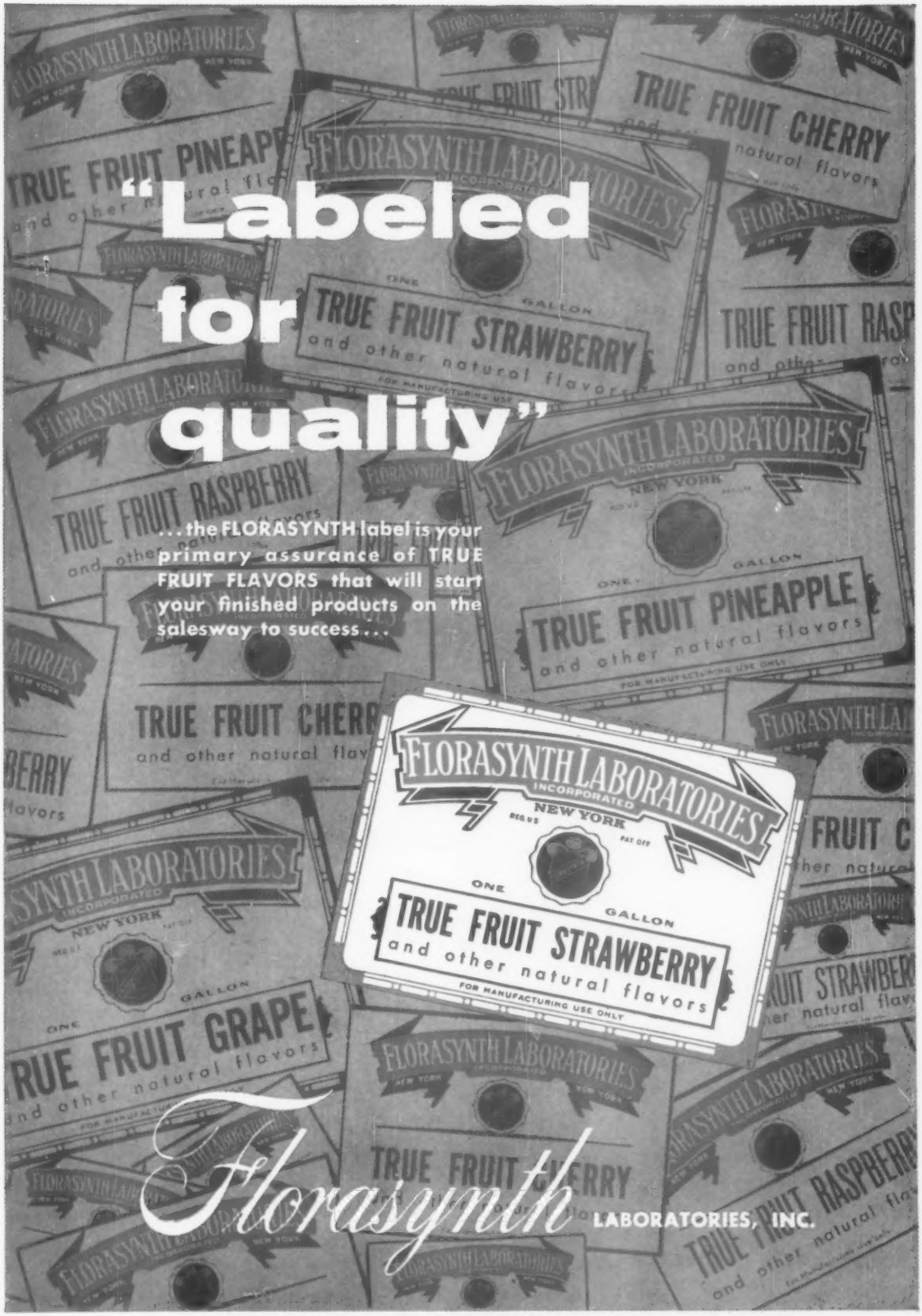
Effect of delayed handling upon shrimp quality during subsequent refrigerated storage. E. A. Fieger, M. E. Bailey, and A. F. Novak.

Evidence presented stresses need for rapid processing of freshly caught shrimp. For superior quality retention during ice storage, shrimp should be removed from trash fish and headed within an hour or as soon as possible after being caught. This treatment should result in removal of sand veins, high in bacteria, and may retard melanosis appreciably during ice storage. Adequate washing after heading should also contribute a beneficial effect on the ice storage life of the product. (See page 297)

Packaging — *Prepackaged meat*

Factors affecting quality of prepackaged meat. IV. Microbiological studies. B. Effect of package characteristics and atmospheric pressure in package upon bacterial flora of meat. Frank E. Halleck, C. Olin Ball, and Elizabeth F. Stier.

Storage temperature, storage time, packaging material, and initial bacteria counts had effects on bacterial growth in packaged meat. Primary effect of packaging materials on bacterial growth showed significant correlation with



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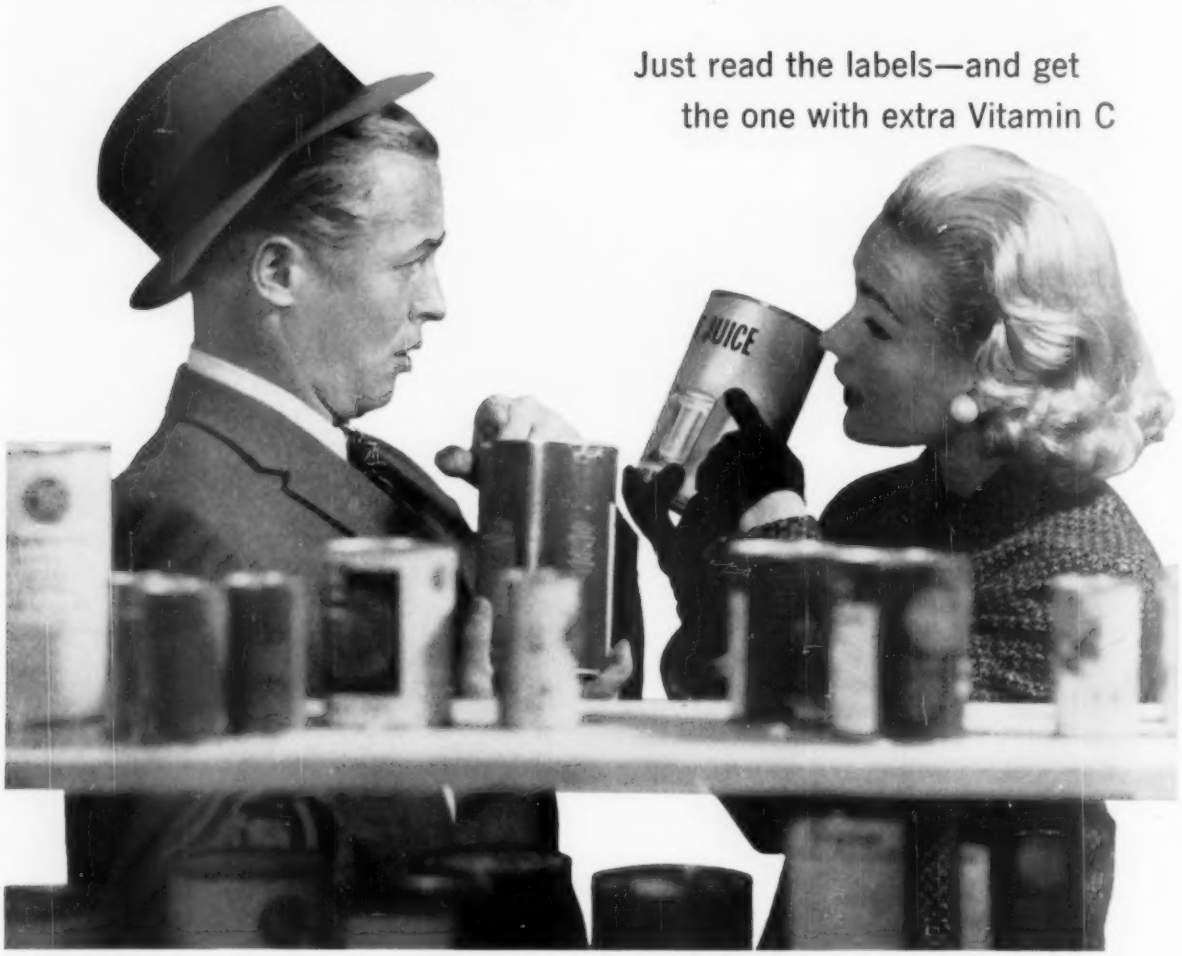

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the gas-water vapor permeability of the materials. Permeable films (cellophane, cellulose acetate, and polyethylene) permitted growth at optimal rates until dehydration or mold growth interfered. Growth rates in the permeable films was controlled by storage temperature only after completion of the lag growth phase. Population maxima were attained at the same time that dehydration and mold growth were prevalent. Non-permeable packaging materials (the can, cellulose acetate-pliofilm laminate, and cellophane-pliofilm laminate) influenced bacterial growth by the atmosphere produced within the container. Growth in these materials was marked by a longer lag phase than in permeable films. Bacterial growth seemed to be specific for the packaging material. Cellophane-pliofilm laminate inhibited bacterial growth more than other packaging materials. Vacuum in this package was a contributing factor in the inhibition of growth. (See page 301)

Freezing *Strawberries, raspberries*

Time-temperature tolerance of frozen foods. XIII. Effect of regularly fluctuating temperatures in retail packages of frozen strawberries and raspberries. D. G. Guadagni and C. C. Nimmo.

Results from carefully controlled experiments indicate that fluctuation *per se* is not an important factor in quality change in commercially packed frozen strawberries and raspberries. Storage of frozen raspberries and strawberries at steady and fluctuating temperatures in the ranges of −10° to +10°, −5° to +5°, 0° to 20°, 10° to 30°, and 15° to 25° F. has shown that the effects of fluctuating temperature can be explained on the basis of the *effective steady temperature*. Effective temperature is determined by the temperature coefficient in the range of the fluctuating cycle and the amplitude of the cycle. Variations in frequency of temperature cycling had no effect on rates of chemical change, provided the amplitude remained constant. Chemical, physical, and organoleptic data are presented to support the conclusion that fluctuating temperatures do not cause important changes other than those which can be predicted on the basis of steady temperatures. (See page 306)

Additives *Sodium iso-ascorbate*

The effect of sodium ascorbate and sodium iso-ascorbate on the quality of frankfurters. Franklin Mills, D. S. Ginsberg, Betty Ginger, C. Edith Weir and G. D. Wilson.

Processing time may be reduced when using sodium iso-ascorbate in the formulation of skinless frankfurters. A more tender, juicier product may be produced by the accelerated process if it results in a higher moisture and/or fat content in the final product. In these experiments control frankfurters, with no ascorbate, were processed by standard procedures and the anticipated losses due to the longer processing time were compensated for in the formulation. Under these conditions there were no significant differences in tenderness and juiciness between frankfurters containing sodium iso-ascorbate and similar products containing no ascorbate. Frankfurters containing sodium iso-ascorbate or sodium ascorbate had a brighter and more desirable internal color than controls prepared in a similar manner. The color was uniform, and under-cured products were not found in the experimental lots. (See page 311)

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The Functional Value of Food Additives[a]

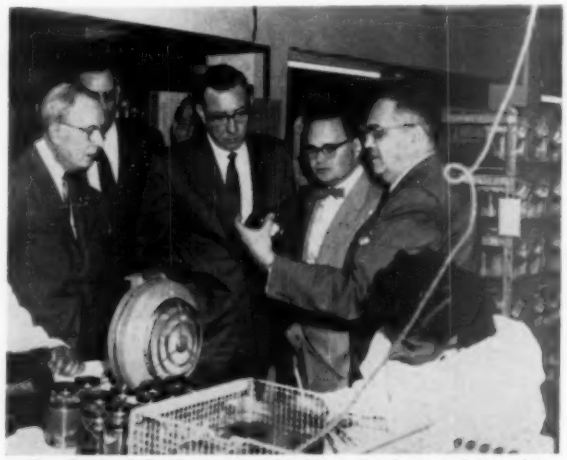
Bernard L. Oser, Ph.D.

Food and Drug Research Laboratories, Inc., Maurice Avenue at 58th Street, Maspeth 78, New York City

BILLS DESIGNED TO IMPROVE regulatory control of food additives have been incubating in the laboratories of Congress for the past 5 years. So far the only law to hatch from this process has been the Miller Amendment covering the use of pesticides. Failure to produce a corresponding law with respect to intentional food additives may be attributed to both environmental and genetic factors. From the environmental standpoint it could be said that much light has been cast on the need for such legislation but perhaps not enough heat has been turned on. However the major difficulty has been genetic, i.e. unsuccessful cross-fertilization of germinal ideas within the regulated industries or between them and the government.

It is to one of these controversial issues that I propose to address myself today, namely whether functional value shall be assessed by the regulatory agency in considering the introduction of any new food additive. I foresee a real danger that industry's reaction of "no pasaran" to this proposal may lead to further delay in enacting a Federal amendment with the consequent threat of non-uniform state and local legislation.

[a] Presented before the Section on Food Drug and Cosmetic Law of the New York State Bar Association, New York City, January 29, 1958, and reprinted by permission of Charles Wesley Dunn, Chairman of the Section.

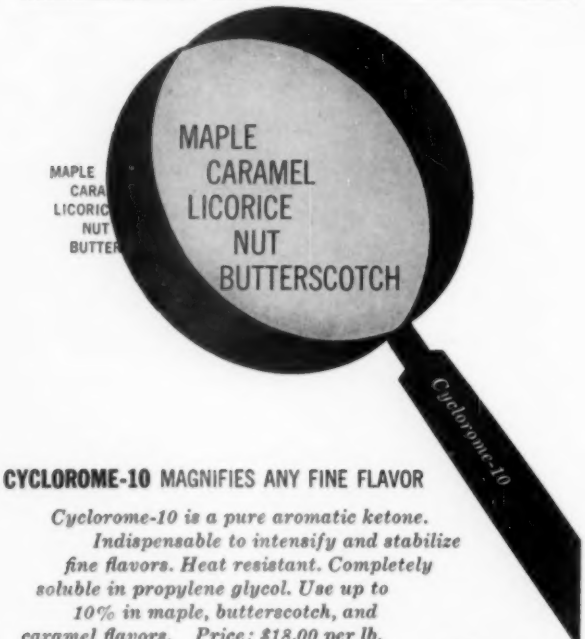


Dr. Bernard L. Oser shows health and science subcommittee members some preserved animal organs. These were taken from one of the test animals which had been fed a diet containing an additive under evaluation. Such organs are examined microscopically to determine if they have been damaged. Looking on are, left to right, Dr. Will E. Neal, Republican of Huntington, W. Va.; Kurt Borchardt, the committee's legal counsel; John Bell Williams, Democrat of Raymond, Miss., who is chairman of the subcommittee; and Dr. Myron Brin, FDRL's chief biologist.

There is no doubt that food additives are intended to serve some useful purpose. Every bill now before Congress defines additives in terms of intended use. The voices of the health officials, the medical professions, and the consumer have been raised repeatedly against the purposeless addition of any non-nutritive substance to foods. To suggest that this does not coincide with the view of responsible industry is to build a straw man. Food producers and processors have, in fact, invited closer regulatory control over useful food additives. The question with which we are here concerned revolves around whether this control shall be limited to the issue of safety or shall include also an evaluation of usefulness.

USEFULNESS

Without entering into a semantic discussion of the subtle distinctions between such terms as utility and functional value, let us examine how various agencies



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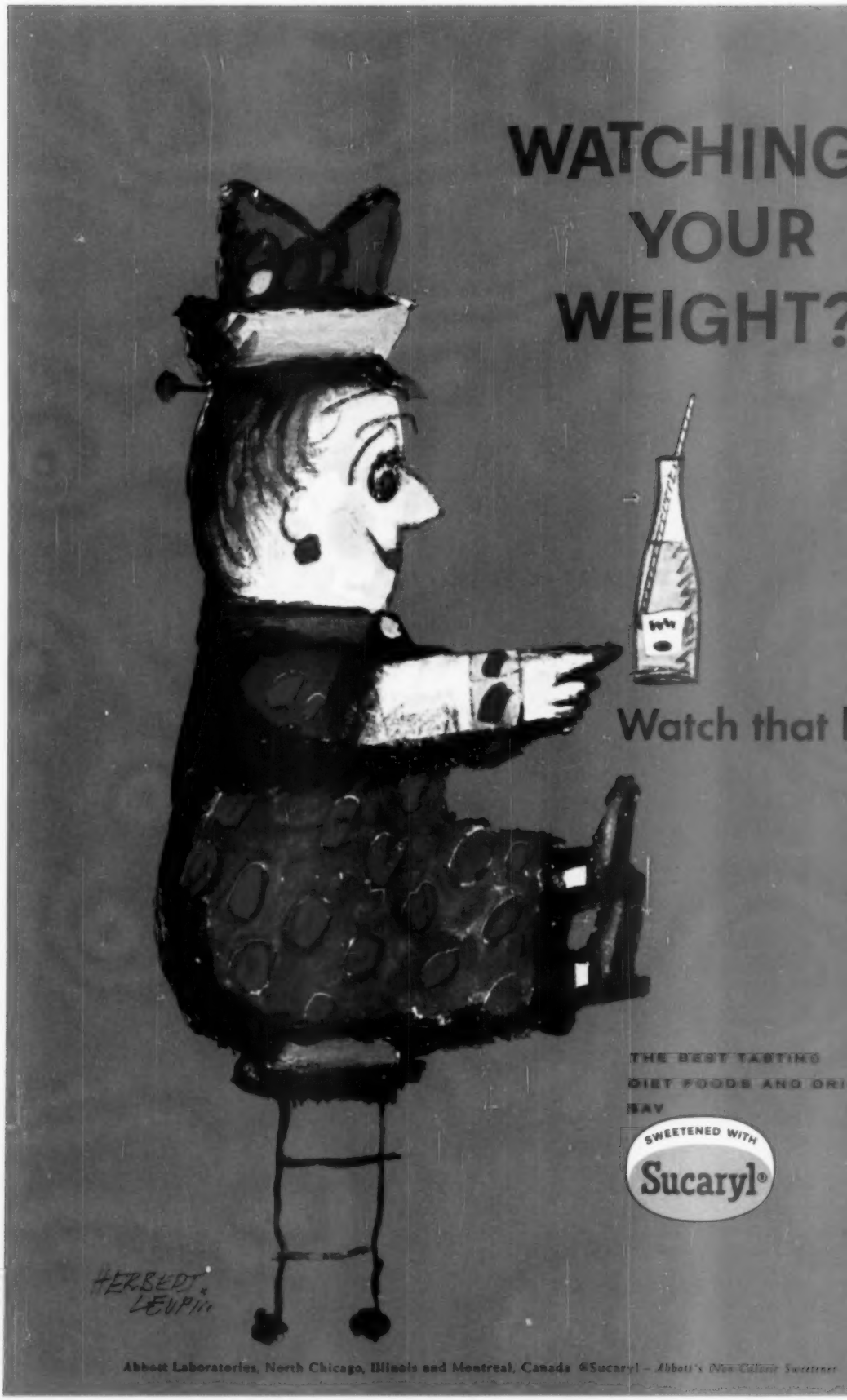
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1 tsp. vanilla
1 square (1 oz.) unsweetened chocolate
¼ cup boiling water
2 egg yolks
½ c. nonfat dry milk solids
½ c. ice water
⅛ tsp. cream of tartar

Brush 8-inch pie plate with oil; coat sides and bottom with coconut. Set aside. To cold water, add gelatin, Sucaryl, salt, vanilla; set aside. Melt chocolate in double boiler; add boiling water; cook and stir until smooth; remove from heat. Add unbeaten egg yolks; stir until blended. Add gelatin mixture; stir until smooth. In chilled bowl, beat milk solids with ice water and cream of tartar on high speed until stiff peaks form. Add chocolate mixture slowly while beating on low speed. Pour into pie plate. Chill until set. Serves 6.

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have expressed the concept that food additives must be useful. The Food Protection Committee of the National Research Council *(5)* and the American Public Health Association *(7)* have adopted the principle that "A decision to use an intentional additive in foods should be based on the assurance (a) that it will be safe, and (b) that it will benefit the consumer." The Joint FAO/WHO Expert Committee on Food Additives has taken a similar position in its report *(1)* discussing the "circumstances in which there is technological justification for the use of acceptable food additives *to the advantage of the consumer.*" (Emphasis supplied.) Spokesmen for the Food and Drug Administration have expressed their views on this subject several times during the past year. At the Congressional subcommittee hearing last year, Commissioner Larrick *(3)* testified that "We think they (food additives) should be permitted only when there is some definite benefit to the producer or consumer to justify the risk involved" *(4)*. This extension of the allowable benefit to the producer was repeated by Mr. William W. Goodrich, General Counsel for the Food and Drug Administration, when he stated *(2)* that "Public opinion will be satisfied only by a rational justification based on considerations of food technology or consumer benefit coupled with assurance of safety of the proposed use." He went on to interpret consumer benefit as including "a use which benefits him directly in terms of product improvement or food convenience, or indirectly in terms of improvement in food processing, storage, packing, or other steps in moving the food from its raw state to the dinner table." The view that technological advantage is included in the broad concept of consumer benefit was also expressed by Mr. W. B. Rankin, Assistant to the Commissioner, in a recent address *(6)* before the Manufacturing Chemists Association.

Probably the most extensive description of justifiable uses for food additives is contained in the FAO/WHO report cited above. Included are

(a) maintenance of nutritional quality, such as by the use of antioxidants.

(b) enhancement of keeping quality or stability, with resulting reduction in food wastage, through the use of antioxidants, antimicrobial agents, inert gases, meat cures, etc.

(c) enhancement of attractiveness of foods by means of coloring and flavoring agents, emulsifiers, stabilizers, thickeners, clarifiers, and bleaching agents. (That appeal to the eye as well as the palate is not a mere whim of the food producer, is recognized by all nutritionists, since proteins, vitamins, and minerals serve no purpose unless eaten.)

(d) providing essential aids in food processing. Agents which function in this capacity include acids, alkalis, buffers, sequestrants, and various other types of chemicals.

(These and similar acceptable uses are also described in the Publication 398 of the Food Protection Committee entitled "The Use of Chemical Additives in Food Processing.")

It is noteworthy that useful additives may accrue not only to the direct benefit of the individual consumer but indirectly to the benefit of the public generally, by conservation or enhancement of the food supply. Moreover enhancement of the nutritive value by means of an additive, be it a protective agent or a nutrient per se (such as a vitamin or amino acid) should be considered in terms of the food itself, not in terms of the diet as a whole. Whether or not such an additive is desirable from the standpoint of the nutritional needs of the population, should be determined under other administratitve authority, and not be confused with the issue of the safety of food additives.

NON-USEFULNESS

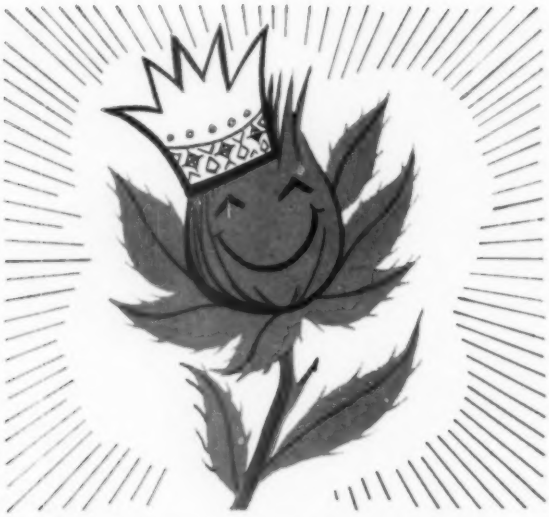
Highly significant is the emphasis placed by the FAO/WHO report on situations in which food additives should not be used. These include uses which disguise faulty, or careless, processing methods; which encourage unhygienic conditions of handling; which result in deception of the consumer; which cause substantial loss of nutritive value; or finally, "when the desired effect can be obtained by good manufacturing practices *which are economically feasible.*" (Emphasis supplied.)

Citation of the situations enumerated by the FAO/WHO committee in which food additives should not be used, would be incomplete without mention of the fact that existing provisions of the Federal law prohibiting adulteration and misbranding of foods provide ample protection against deception, filth, and depreciation of nutritive or economic value. It is not from this point of view that the consideration of functional value of food additives needs to be justified.

The reference to good manufacturing practice recalls one objection raised to granting administrative authority to pass upon functional values, namely that control over manufacture is beyond the scope of a public health measure so long as protection against adulteration and misbranding is assured. A good illustration of a situation that might arise, is to be found in the testimony of Commissioner Larrick concerning the possible use of formaldehyde in milk. Despite the fact that a harmless amount of this substance can function as a highly efficient preservative, its use would be prohibited on the ground that departure from "good manufacturing practice," viz., the use of refrigeration, pasteurization, sterilization, etc., should not be permitted. Were safety under conditions of use the only criterion, it seems unlikely that this use of formaldehyde could be prohibited from milk.

"FUNCTIONAL VALUE"

The argument that consideration of functional value would be an intrusion of the Government into control of technological practice overlooks the fact that the Food, Drug, and Cosmetic Act gives the administrator authority to consider what constitutes good manufacturing practice, in relation to the presence of added poisonous or deleterious substances [Section 406(a)]. Similar authority is exercised quite extensively in the promulgation of definitions and standards of identity of foods and, directly or indirectly, through factory inspection. If what consti-



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tutes good manufacturing practice can be given weight in situations concerning sanitation or "honesty and fair dealing" it seems not unreasonable that it may deserve attention in safety evaluations.

Since the Administration Bill (H.R. 6747) contains practically all of the features to which industry witnesses have taken exception, let us examine how it takes functional value into account. In the first place a "chemical additive," by definition, must be intended to preserve or alter food or be used "for any other purpose in producing, manufacturing, packing, transporting or holding food." (The definitions in all other bills contain a similar provision, except H. R. 8112 (Rep. Miller) which describes use as "the intentional addition . . . for the purpose of imparting a desired quality to the food.") H. R. 6747 goes on to require not only a statement of the conditions of the proposed use (without which a decision as to the safety under conditions of use would hardly be possible) but "all relevant data bearing on the functional value" of the additive. This is for the purpose of a later section which provides that the regulation permitting the additive shall not issue unless, inter alia, the administrative agency is satisfied that the "proposed use has functional value." An exception to this provision is made "if he (the Secretary) finds that such additive is not a poisonous or deleterious substance."

From what has already been said it seems reasonable to expect that the Food and Drug Administration intends to construe functional value broadly, to comprehend, in effect, any use which enhances the nutritive value, stability, acceptability, or economy of food, aids in its production or technology, and does not encourage unsanitary handling. The Administration has professed its willingness to depart from the present "necessity rule" as applied to poisons per se and to adopt the principle of safety under conditions of use, provided the additive is useful. However, the limitation of consideration of functional value to "poisonous or deleterious" additives provides no basis, other than the per se doctrine, for ascertaining whether or not a substance is exempt from such consideration.

Past experience tells us that very few additives, old or new, could escape being classified as poisonous or deleterious by the per se yardstick. If toxicological data obtained at a dosage level deliberately set high enough to induce an adverse response were to be used as the basis for defining a poison, practically all substances would fall into this category. But if the new approach to food additives is designed to replace this impractical per se doctrine with an alternative better geared to modern technological advancement, it will be necessary to delineate more clearly the special circumstances under which weight may be given to functional value. If these circumstances can not be specified in the language of the statute they should at least be specified in the legislative history of the proposed revision of the law and not left to administrative or judicial interpretation.

SOME ASPECTS OF SAFETY EVALUATION

For a full appreciation of the role of functional value in assessing the permissive use of food additives, it may be profitable to explore a bit some aspects of safety evaluation. As is often the case in discussions of this subject, we must remind ourselves that all things are relative; safety, necessity, and value, whether functional or otherwise, are terms which have no meaning in the absolute sense. In a paper published in 1953 in the Food Drug Cosmetic Law Journal, I elaborated on the thesis that poisons do not exist in a vacuum *(4)*. Similarly, "safety" or "harmlessness" are relative, regardless of how "reasonably certain" we may be of judgments derived from human experience or animal experiments. If we acknowledge that safety to all persons under all conditions can not be established with absolute certainty, it must be admitted that some residue of uncertainty remains. To minimize it, it is customary in the practical application of toxicological data, to allow a "margin of safety." This is, strictly speaking, a margin for uncertainty and its magnitude is dependent on many factors. It presumably takes care of differences in susceptibility between species and strains of animals, and for variations in human response due to age, disease, dietary habits, or physiological stresses. Safety evaluations must take into account the nature of adverse effects induced by excessive dosage and particularly whether these are irreversible or cumulative. Fortunately most food additives are intrinsically provided with brakes or warning signals, in the sense that undesirable effects in flavor, appearance, or texture, or technological difficulties in processing, guard against their excessive use. In such cases, and especially when their toxicity as judged by animal tests is of a low order, it is not necessary to establish maximum limits or tolerances. On the other hand where sufficient built-in protection does not exist and the toxicological evidence justifies it, a maximum limit must be set on the use of the additive, the level being in the "safe" range but no greater than that needed to do the job. Implicit in such cases is the possibility that amounts above the tolerance may approach, if not enter, the hazardous zone.

In view of the existence of a residual risk, however small, the Food and Drug Administration in its bill has claimed the prerogative of weighing this risk against the advantage to the producer or consumer. The exception, where the "additive is not a poisonous or deleterious substance" is couched in language which has proved so vague and impractical under the present law that it should, in my opinion, be replaced with a more realistic criterion. It is suggested that *only when the nature of the additive and the toxicity data are such as to require a tolerance limit on its use, should functional value be a proper consideration in a safety evaluation.* Through this approach, the rejection of a proposed use would be based not on alleged lack of utility but rather on the paramount issue of insufficient safety. And this would apply only to additives where the degree of safety under conditions of use required that quantitative limits be

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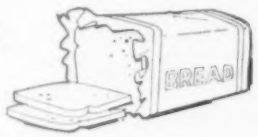

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established. Any intended use, even if safe, which constituted adulteration or misbranding, could be nipped in the bud by warning the petitioner to this effect without confusing this issue with the safety of the food additive. Disputes concerning safety under conditions of use could be more readily resolved by experts or by the courts than can questions of functional value involving subjective or esthetic considerations, consumer preferences, and the like.

SPECIFIC NEEDS

The Food and Drug Administration has agreed to "support legislation that permits even poisonous chemicals to be used at apparently safe levels, provided that in such cases the chemical serves some function that warrants taking the minimal margin of risk." If FDA were to go a step further and define its terms more specifically, I think the present roadblock would be removed. In short, what are needed at this point are

1. A comprehensive statement of acceptable functional values which might serve as the basis for regulations for the administration of a food additives amendment. The FAO/WHO report could well be considered as a pattern for such a statement.
2. A substitute for the per se terminology in H. R. 6747 whereby substances "not poisonous or deleterious" are exempted from consideration of functional value. I submit that the latter should be limited only to such substances as require the establishment of maximum tolerances.
3. Finally, a clear understanding that rejection of a proposed food additive would not be based merely on its alleged lack of functional value, but on considerations related to safety for use under conditions of use.

May I conclude by suggesting, somewhat belatedly, a better title for this paper: "The Futility of Feuding Over Utility."

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IFT News

The Food Technologist — Selections from a Symposium[a]

What Management Expects from the Food Technologist

W. W. Hudson,
Gerber Products Co.

MANAGEMENT NOT ONLY EXPECTS the leadership in technical groups to comply, but it expects these people to gain *the willing cooperation of their staffs.*

Closely allied to the first point is that of cooperation generally. Cooperation not only within your own groups, but with the other departments of the organization such as sales, production and accounting or finance. One could spend the whole time elaborating on this one subject as it involves human relations, communications and, yes, even compromise.

Management expects all divisions or departments to cooperate with each other as you won't have a winning team without close cooperation between the defensive and offensive units, the coaches, the backfield men, and the linemen.

Naturally, management expects you to apply yourself to your present job with all diligence. Sometimes you find a person who is so busy thinking about things they could do to improve efficiencies in other departments of the company, they are not accomplishing as much as they otherwise could on the job that they are actually on. I might refer back to cooperation again and say that you are expected to place your own job first. Get it done completely and effectively before you devote too much of your time in helping or criticizing others. This requires good judgment and, in many cases, diplomacy.

Management expects a person to be aggressive and and alert. Nobody likes a person sitting around on the middle of their spine with their mouth hanging open; but don't confuse aggressiveness and alertness with running around making a lot of noise and confusion, or with sticking your nose into other peoples' business, or with always insisting on being heard on a subject that you don't have any constructive ideas to offer. Aggressiveness and alertness are synonymous with efficiency and, in most cases, with quiet and orderly progress. Don't be afraid that the boss won't recognize it—he will.

Management looks for *imagination and creative ability* in its technical staff. Much of science is based on cold logic—the ability to start with a premise and reason from point to point to a logical conclusion. This not only applies in research, but in quality control or in management problems which have technical or semi-technical aspects in them. I don't believe it would be any exaggeration to say that imagination and creative ability sort the men from the boys in all aspects of management.

One of the most difficult jobs that management has had, particularly in the last 10 or 15 years, has been to get people who are willing to take responsibility. In the so-called "good old days," each individual failed or succeeded because of his own abilities and willingness to assume risks and responsibilities. Perhaps it is the development of this complex society in which we live that has lessened the willingness of a person to take responsibilities and stand or fall on the results of his own decisions. If you have the ability of getting things done through people, and are willing to take the responsibility for your own actions, you have an unlimited horizon before you.

In addition to taking responsibility in your own job, management expects you to prepare yourself for greater responsibilities. Many companies are using their technical departments, such as research, quality control, and industrial engineering, as training grounds for developing supervisory and management personnel. With all of the technological advances, which will continue at an accelerated rate, I feel this is very sound.

In preparation for better jobs and greater responsibilities, the company can and should offer opportunities for schooling and broadened experiences. However, the primary desire and effort must come from the individual. If he isn't willing to make the personal sacrifices and expend the effort on his own time to fight his way up against all odds, he isn't the stuff of which successful top executives are made. He had better marry the boss's daughter! Just because we happen to be in a sellers' market on scientists and engineers at the moment, don't forget that there is only one president and director of research in a company—the competition is as tough as ever.

As you know, a specialized technical education is a great asset in today's world, but it is also important to recognize that it has some drawbacks. There simply isn't time in a four or five year college course to give you the necessary scientific foundation and also give you a broad grounding in business administration, business law, accounting, industrial relations and the humanities.

[a] Sponsored by the Chicago Section of IFT, November 11, 1957 and held at the Midland Hotel, Chicago. The two remaining presentations will appear in the July issue.

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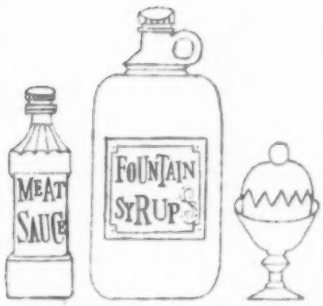

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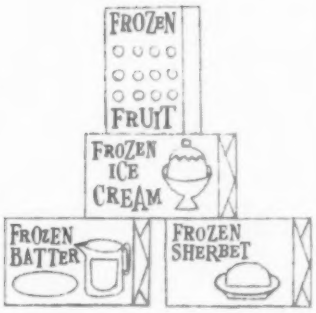

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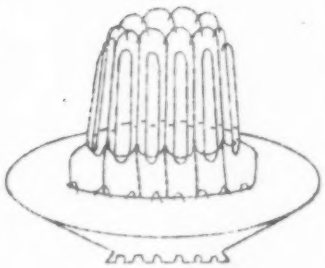

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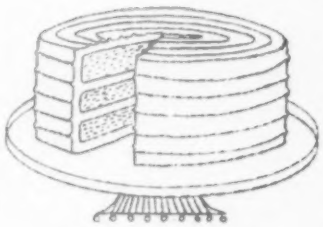

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Yet, a well-rounded individual who is going to make critical decisions for his company must have an understanding of these things. Fortunately, this understanding can be acquired by any normal individual by selected reading and study, by inquiry and attentive listening, by observation and by association.

What the Food Technologist Expects from Management

Roy E. Morse
Rutgers University

LET'S LOOK AT MANAGEMENT through the eyes of the Food Technologist and see what the Food Technologist expects both for his company and for himself. There can be no quarrel that these two objectives are inextricably intertwined and that one serves theother. For the purposes of this discussion let's try to draw an arbitrary line and discuss them separately.

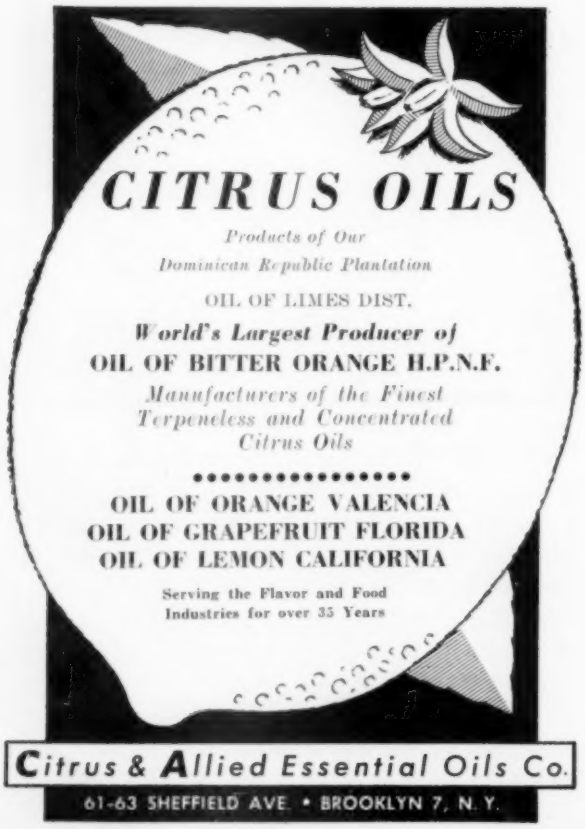
For his company the Food Technologist expects the *best management possible*. In viewing the objectives of management, the procurement of profit could be a great deal better than it is currently. A recent study of profits in the food industry showed the top company obtained a profit of 8.81% as per cent of sales and the tenth was already down to 4.37%. Of the top ten profit makers only about half were primary food processors. This is a pretty slim profit margin considering the scale and effort involved in food processing. This profit picture could be greatly improved by one of the requests the Food Technologist has to make of management, namely an improved use of research and development.

The Food Technologist expects from management *a better climate for Research and Development*. Research and Development should not report to sales, production or any other group; it belongs on management level and to place it elsewhere is to place it in an incorrect environment. R & D depends heavily on a creative atmosphere, great developments are not the result of a "flash of genius," but the result of organized, hard working, creative thinking. This can be stifled much more readily than it can be cultivated.

The Food Technologist expects of management *a more imaginative use of the technical man*. There are extremely few examples of a food company straying into other fields via research to reach more profitable places. The founder of Dow Chemical Company, Willard Dow, raised funds to commercialize the extraction of bromine from salt brine. When this was successfully accomplished the banking investors favored a calm and cool collection of the gains, but Willard Dow inspired by the horizons that had been opened before favored pushing on to new accomplishments. The original investors and Dow parted, but I'll bet they wish now they had stayed with him. What more mundane operation could be envisioned than the extraction of roofing granules from a mining operation, yet look where men of imagination and vision have led Minnesota Mining and Manufacturing Company via R & D.

Finally, the Food Technologist expects of food management *a more active part in basic research on food products*. In general, the only basic work coming out now is issuing from the university and government laboratories. The food industry is content to encourage this work there and do little for itself. What little work is being done is not available for publication and the Food Technologist finds himself in the position of soliciting information from these basic sources but being, by management decree, unable to return the favor. This is basically unethical and deeply troubles the moral standards of the progressive technical man. There is need for a great deal of basic work in the field of Food Technology.

For himself, the Food Technologist expects from management an attitude not generally present now. The attitude needed is one of *encouragement and compassion*. Management constantly reminds the Food Technologist that he is not adept at communicating his ideas and concepts to management, yet rare is the management person in the food industry who will take the time to follow the thought patterns of the Food Technologist. Both lose by this stalemate. Management in the food industry should understand that it is the function of the Food Technologist to be unhappy with things as they are now. That is the best workable definition of research—"There must be a better way to do it than the one we are now using."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REGIONAL NEWS

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A two-week jump in the regular meeting date in April was necessary in order to snare Dr. Axel Olsen of General Foods as a speaker for SCIFTS during his visit to the West coast. An enthusiastic 90 members availed themselves of the opportunity to see and hear the distinguished visitor. SCIFTS was also pleased to welcome the chairman of the Mexico section, Walter McAllister, and his wife.

Dr. Olsen's subject was concerned with Research Planning in Industry, a growing program with which he has had many years of experience. He defined commercial food research as the organized application of science to develop useful profitable solutions to previously defined problems related to the directives which guide the company's business. This covers both corporate and public interest and involves the consumer and consumer demands. It was recognized that the consumer is interested in 1) palatability, 2) *convenience*, 3) economy, and 4) nutrition in that order although some question that nutritional aspects should be the last consideration. The objectives then for commercial research should include:

1) Consumer protection: clean products, protective packaging, keeping quality, and nutritional value;
2) Consumer satisfaction: palatability, economy, convenience, uniformity;
3) Product franchise protection: quality improvement, national surveys;
4) New product business: salable products.

The costs of research and the imperative need for wise and thorough planning of all phases of the research problem including what anticipated uses would be made of it, were discussed in detail. Dr. Olsen cited considerations in a realistic approach to appraising the costs and the instituting of research projects, emphasizing the futility of too wide-spread ambitions for the personnel and facilities available.

In keeping with the trend of the times to alphabetize, Dr. Olsen concluded with a summary of the important aspects to be remembered in developmental programs, as PODCC. Translated PODCC means: Planning, Organizing, Directing, Co-ordinating, and Controlling.

—*Cora Miller*

CHICAGO

Dr. Ira Somers of the National Canners Association discussed highlights of N.C.A. research and showed by slide presentation the application and value of this research in solving canners' problems. Topics discussed included: new processing methods; flavor and color retention; water conservation; spoilage prevention; sanitation; and waste disposal.

Dr. Somers's research has been in the fields of processing, quality improvement and sanitation. One of his outstanding contributions was the development of in-plant chlorination. He is the author or co-author of a number of articles and books in the field of plant physiology and food technology including N.C.A.'s *Laboratory Manual for the Canning Industry*.

DIXIE

The Dixie Section of IFT held its March Meeting at the Glass Container Division of Owens-Illinois in Hopeville, Georgia, on March 14. Mr. Jim Roberts, Owens-Illinois Sales Representative for Food Industries in Georgia made arrangements for the tour and program. This plant, considered the most modern and the finest glass container plant in the world, has been in operation less than one year. It is located in Atlanta because of transportation facilities—railroads, airlines, and trucking concerns. The plant operates 24 hours, seven days a week, with rotated shifts. It employs 850 people and has a 3.5 million dollar payroll.

Mr. Harold Ottenson, plant manager, was guest speaker at the dinner meeting. He told the group that Owens-Illinois is nationwide in scope and also operates in foreign countries. Twenty-eight per cent of the enterprise is located in the state of Georgia and the holdings include forests and a pulp mill at Valdosta. Glass is made from sand, soda ash, and lime, melted at 2700° F. The furnace at the Hopeville plant holds 400 tons of molten glass, uses enough gas to heat 20,000 homes; the 450 H.P. compressors make compressed air to blow the glass containers. The plant manufactures clear as well as colored glass. The sand Owens-Illinois uses comes from Thomasville, Georgia, and is of excellent quality for glass; the soda ash is from Baton Rouge, Louisiana, and the limestone from Tennessee. Eighteen billion bottles are made each year.

Although glass making is in concept an old industry, in many respects it is a new one. Glass beads go back as far as 3,000 B.C.; in 300 B.C. there is evidence that an iron pipe was used to blow glass. The blowpipe was used until 1900. A blower could blow 18 dozen bottles a day. Mike Owens, a glass blower, invented a glass blowing machine a little over 50 years ago and revolutionized the glass blowing industry. Owens-Illinois has a glass technical center in Toledo, Ohio, where work in applied science and basic research is conducted. Glass today has a strength of two per cent; the industry is striving for five to ten per cent strength in the next ten years. We may have glass homes instead of steel ones in the future.

Election of new officers was held at the close of the meeting. They include two Councilors, Mr. Dan Pratt, University of Georgia, Athens, and Mr. Ralph Bohn, Consulting Chemist, Atlanta; Chairman, Mr. Cyril Lovvorn, the Dromedary Company, a division of National Biscuit Co., Woodbury, Ga.; Vice-Chairman, Mr. William B. Cown, Engineering Experiment Station, Georgia Institute of Technology, Atlanta; Secretary-Treasurer, Mr. Angus J. Shingler, Coca Cola Company, Atlanta. The Editor retained her job for another year.

The Section held its April meeting at Columbus, Ga.

In the afternoon the group toured the Tom Houston Peanut Co. and the Nehi Corporation Canning Plant in Columbus. At Tom Houston, we observed the making of candies and the roasting and packaging of peanuts and peanut products. Each member received a paper bag and was invited to take samples.

Columbus, Ga. is the International Headquarters of the Nehi Corporation, makers of Nehi, Royal Crown, and Par-T-Pak beverages. The canning plant manufactures canned beverages, including a 12-ounce size of carbonated Nehi orange, Nehi grape, Nehi ginger ale, Nehi cola-flavored non-sugar dietary drink and Nehi strawberry; also a non-carbonated chocolate-flavored drink to be served either hot or cold. Drinks were on the house. Next stop was the new Nehi Bottling Plant between Columbus and Fort Benning, Ga. Here two sizes of carbonated beverages are bottled, a regular 10-ounce size and a quart size. Several of the group did a little sight-seeing in Fort Benning between the afternoon tours and the dinner meeting which was held at the bottling plant.

Mr. Bill Miller, chemist, welcomed the Dixie Section to Nehi Corp. Mr. Don O'Brien, Research and Technical Service Division of American Can Co. and former chairman of the Florida Section, was guest speaker. He has been with the American Can Co. since 1951. Mr. O'Brien showed slides of defective cans and also processes of can manufacture. He had some canning records dating back to 1893-94, and from these we learned that some of the problems in the canning industry today are the same as then.

In 1810 Peter Durand, an Englishman, applied for a patent for a "tin cannister" which was later shortened to "can." It took a while before a metal container industry was developed but nevertheless that industry is now a little over 100 years old. The first cans were cut, formed, and soldered by hand. They were "cap and hole" cans and were made about the turn of the century. During the 1920's the forerunners of the present can sealers were used. Fifty-eight percent of cans used today are used for food products; processed fruits and vegetables account for 34 percent of the cans used annually. Carbonated beverages require a stronger can than most products

Artist's concept of the new food technology building at the University of Georgia, Athens. Floor space in excess of 48,000 square feet is available for laboratories, classrooms, and offices. This fine new million dollar facility will be ready for occupancy in the fall of 1959, and it can be anticipated that it will return many times its cost in research services on behalf of the food industry of Georgia and the nation.

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Tin plate has a high-grade steel base, coated on both sides with a thin layer of tin. Tin is non-toxic. To retain the color in some products tin is the essential packaging material. Eighty percent of cans produced today are tin-plated by the electrolytic process. This process has largely replaced the former method, dipping.

Oleoresin coatings were the first coatings used on cans; now organic or enamel coatings are used. Three-fourths of the cans used today are enamel lined. C-enamel was developed for canned corn to prevent darkening.

The synthetic rubber used today as sealing compounds around the rim of lids is found to be better than natural rubber for this purpose.

Today there are over 150 different specifications for tin cans. They are "tailor-made" so to speak for each product canned. Experimental packs of foods are stored to test the durability of new cans. No accelerated test can take the place of this expensive, time-consuming test. Aluminum cans are useful for many products; however, they cannot be soldered, but must be cemented.

—Cordelia Ellis

GREAT LAKES

The spring meeting of the Great Lakes Section was held April 18, 1958 at the Dow Chemical Company, Midland, Michigan. The morning program consisted of plant tours through the Continental Can Corporation Fiber Drum Plant, and the Dow Chemical Plastics Building.

Dr. Emil M. Mrak, President of the Institute of Food Technologists, addressed the group following the luncheon at the Midland Country Club. Dr. Mrak gave a very inspiring talk on education, research and the food technologist. Dr. Mrak outlined the problems that had been faced by the University of California Food technology group and how they had proceeded to solve these problems. Dr. Mrak's talk was a very inspiring presentation on the importance and future of Food Technology.

The afternoon technical session consisted of four technical papers presided over by Dr. C. R. Scott of the Dow Chemical Company. The following papers were presented at the afternoon technical program.

"Microanalytical and Microbiological Techniques in Food Plant Sanitation," by Dr. V. S. Troy, Senior Microbiologist, The Continental Can Company, Inc., Chicago, Illinois. After reviewing some of the past history of control legislation and the development of techniques for estimation of filth, Dr. Troy pointed out that sanitation is an economic necessity, that microanalytical and microbiological techniques can be applied by management to determine the efficiency of a plant processing operation and can be used as a tool of management for producing a higher quality product and for controlling the uniformity of the product. Also, microbiological and microanalytical techniques give data for the re-design of plant equipment and processes. Dr. Troy concluded his talk with a series of slides illustrating good and poor sanitation practices.

"The Use of Polymers in Reducing Waste Pollution," by T. J. Powers, Superintendent, Waste Disposal Plant, The Dow Chemical Company. Mr. Powers reviewed for the group the construction and operation of the Dow Chemical Waste Disposal Plant. The problems of the Dow Chemical Company parallel the problems of many of our present day food plants that have large quantities of process waters containing hard to dispose of wastes coupled with small watersheds and other economic factors that make it difficult to get rid of these wastes. The highlight of Mr. Powers' presentation was a demonstration of precipitating or coagulating colloidal solids using organic polymers. Selective agents were added to one of a pair of silica, brine, cellulose, corn starch, and tomato waste samples, clearly demonstrating how these polymers can be used in concentrations as low as one or two parts per million to rapidly precipitate the colloidal material in these wastes.

"Calcium Disodium Versenate, A New Chelating Agent for the Food Industry," Dr. F. J. Butt, Technical Service and Development Department, Dow Chemical Co. Dr. Butt introduced the group to chelating agents, discussed their chemical formula and how they tie up metallic ions. He pointed out that chelating agents are in use at the present time in different types of soil application, to reduce water hardness, as a de-scaling compound and as corrosion inhibitors. Dr. Butt summarized the use of chelating agent in foods in the following manner: (1) Chelating agents can prevent the precipitation of metal salts. (2) They can prevent taste and aroma changes, (3) They can prevent discoloration as in asparagus.

"A New Coating for Frozen Meat, A Cooperative Study," by W. M. Westveer, The Dow Chemical Company, and Professor L. J. Bratzler, Michigan State University. Mr. Westveer discussed the technical aspects of the new hot dip coating. He pointed out that most wraps for meat are not skin tight which permits ice crystals to form in the air pockets. These are unsightly and of course, the ice is water that is moved out of the food product. Dr. Westveer used slides to illustrate how the hot melt is applied and pointed out that the thickness of the coating can be controlled, at least within limits, by the temperature of the hot melt.

Professor Bratzler discussed the acceptability aspects of the hot melt protective material. Dr. Bratzler showed slides where the hot melt, Cry-O-Vac and aluminum foil wrapping were used on identical meat products. The results of Professor Bratzler's tests indicated that all three wrapping materials were equal as far as flavor, tenderness and lack of rancidity or off flavors were concerned. The photographs presented by Professor Bratzler indicated that the hot melt coating preserves the surface color of the meat.

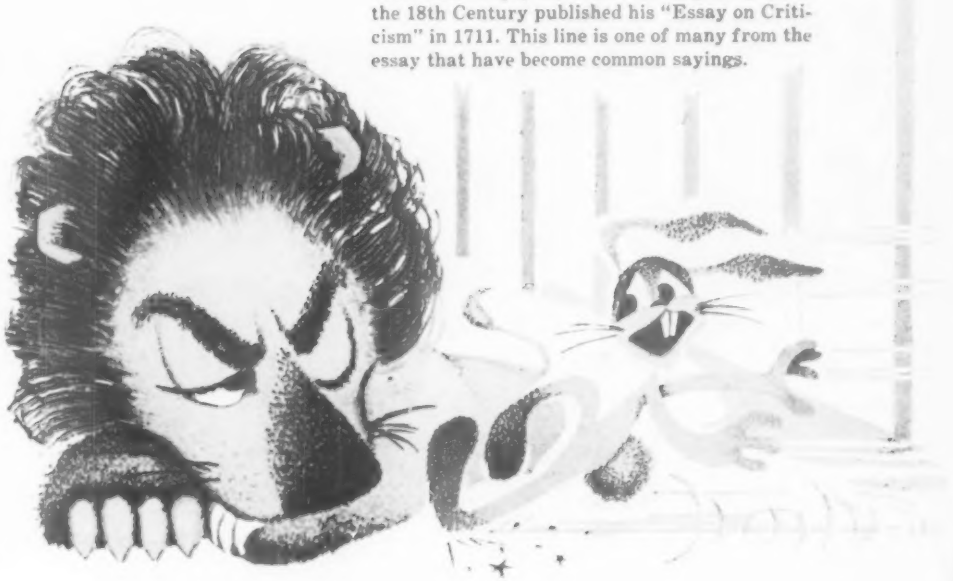
Following the afternoon technical session, Dr. D. D. Irish, head of the Bio-Chemical Laboratories of the Dow Chemical Company, entertained the group with a very pleasant social hour.

—I. J. Pflug

PROVERB PRATTLE

"Fools rush in where angels fear to tread"

Alexander Pope, the foremost English poet of the 18th Century published his "Essay on Criticism" in 1711. This line is one of many from the essay that have become common sayings.



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W. NEW YORK

The Section held its annual spring meeting on Friday, April 25, 1958, at Rochester, N. Y. The program consisted of a plant trip through Gerber Products Co. in the morning, a luncheon at the Powers Hotel addressed by Dr. Ray B. Wakefield, Director of Research and Quality Control, Gerber Products Co., Freemont, Mich., followed by talks from Dr. David B. Hand and Dr. Z. I. Kertesz.

Dr. Wakefield, who also is the National Treasurer of the IFT, spoke on "Education for Food Technologists." Dr. Hand who is Chairman of the Food Technologists Sub-committee of the Food Protection Committee, National Research Council, and Head of the Food Science and Technical Dept., Cornell University, Geneva, N. Y., gave a paper on "Chemical Additives in Food." Dr. Kertesz, Professor of Chemical Food Science, Cornell University, Geneva, gave a talk on "Food Technology in Turkey and Liberia."

NORTHEAST

The Northeast Section held its annual "Students' Night" meeting March 6th. Some seventy-five Food Technology students attended as guests of the section. The dinner meeting was sponsored by local manufacturing concerns and their suppliers.

Mr. Ray B. Wakefield, National Treasurer, spoke on "Things You Are Not Taught In School" giving some sound advice on the development of certain characteristics, such as, co-operativeness, responsibility, alertness, imagination, tolerance, kindness, and other traits on the job. Management expects results. With good basic training and an active interest in Food Technology, the graduate will be of value to his employer and personally successful if he continues to develop those traits not taught in school which fit him to his particular job conditions.

A feature of the meeting was the presentation of the Gerber Baby Food Scholarship award plaques to Miss Yorkette Solomon, Department of Food Technology, University of Massachusetts, and Mr. Herbert S. Waxman, Department of Food Technology, Massachusetts Institute of Technology.

The plaques were presented by Dr. William B. Esselen, Head, Department of Food Technology, University of Massachusetts and Dr. B. E. Proctor, Head, Department of Food Technology, M.I.T.

The April meeting featured the election of Section officers for the 1958–59 season. Those elected were: Chairman, E. R. Barron, Vice Chairman, E. E. Anderson; Secretary, Earl McFee; Treasurer, John T. R. Nickerson; National Councillor, Jean Caul; Section Councillors, F. J. Francis and Raymond Swain.

The speakers this 1957–58 season have included Mr. Clifford J. Robertson, Eastern Regional Technical Sales Representative, the Proctor and Gable Distributing Co.; Dr. Emil Mrak, President of IFT; Mr. Frank Sweeney, Food Broker, Barclay, Brown and Jones, Boston; Mr. Tyler R. Stevens, Sales Manager of the Continuous Mixing Department, American Machine and Foundry Co.; Mr. Ray B. Wakefield, Gerber Products Co., and Mr. Clifford L. Blair, the Du Pont Co.

The Northeast Section cordially invites members of other sections to attend its meetings.

—*Arthur S. Levine*

OHIO VALLEY

The Section held its Spring Meeting on March 21, 1958 at the new Continental Can Company plant near Sharonville, Ohio. The co-chairman, John E. Hall, opened the meeting by introducing Mr. Adolph Schwartz who extended a warm welcome to the IFT group on behalf of the Plant Manager, Mr. Lynch, who was ill. A movie on can and steel making by the U. S. Steel Co. was presented after which personally conducted tours throughout the plant were made. Opportunities were provided for viewing at close range the facilities and manner of operation for making metal cans. The lithographing and coating of can body tin plate was also observed.

Role of Food Technology in Management

After the tour and the business meeting, an interesting and informative talk was given by Dr. I. J. Hutchings, Director of Research, the H. J. Heinz Company, Pittsburgh, on "The Role of Food Technology in Management." He told of the importance of the food industry in the world today and of the role of food products in an era of marked population increases. He described the plan of organization of the H. J. Heinz Company and explained the steps by which a new product is developed. The work of a Screening Committee, the Chefs, an Operating Committee, the Executive Sampling Committee and others engaged in package and label development was described. He told of the preparation for a test market in 3 locations and of the use of a national consumer panel. Dr. Hutchings pointed out the three-fold function of the Food Technologist:

1. Production of the finest product possible in color, flavor and nutrition,
2. at reasonable price to consumer, and
3. with profit to the company.

A delicious dinner was served to members and guests in the plant dining room.

Creative Imagination and Brainstorming

The after-dinner speaker was Mr. Glen E. Mitchell, Manager, Personnel Training and Development Department of the Kroger Company, Cincinnati, who spoke on the subject, "Creative Imagination and Brainstorming." Mr. Mitchell defined brainstorming as "an attempt to get a group to think together." He said that the usual steps in thinking are definition, inspiration, evaluation and action. He described the mind as having two parts:

1. A creative mind used for visualizing, foreseeing, imagining and generating ideas, and
2. A judicial mind used for analyzing, comparing, choosing and rejecting.

In a brainstorming session the two parts are kept separate. Ideas are obtained with the creative mind and the emphasis is on quantity of ideas. Evaluation of the ideas is done by other methods than brainstorming. All of us are self-appointed judges of our own ideas and we censor our ideas before we explore them or express them. Express the idea—it can be polished up later. Another principle is to try for quantity. The more ideas you come out with, the more apt you are to develop a good one.

These principles, along with many others, are being effectively used to solve problems in many organizations today. Progress is being made in applying the principles through group brainstorming sessions. Both the direct results and the side effects of these group sessions make them worth trying. There's a gold mine between your ears—why not do some systematic digging?

A vote of thanks was expressed to the speakers for their challenging talks and to the Continental Can Company for their generous hospitality.

At the business meeting, the following officers were elected for the 1958-59 term: Florren E. Long, President; Radcliffe Robinson, Vice-President; Wilbur Gould, Secretary-Treasurer; Margaret Andrew and Robert N. Johnson, Executive Committee (1 year) and Eugene Grab, Executive Committee (2 years).

—Florren E. Long

Phi Tau Sigma

Control of Q fever, a disease found in milk, was discussed by public health experts on April 24, 1958, at the University of Massachusetts during a seminar sponsored by Phi Tau Sigma, honorary food science society.

Speakers were Harold B. Robinson, chief of the milk sanitation section of the United States Public Health Service in Washington, D. C.; Robert C. Thomas, bacteriologist stationed at the Robert A. Taft Sanitary Engineering Center, Cincinnati; Dr. Ralston B. Read, Jr., assistant professor of bacteriology at the University of Massachusetts and president of the University of Massachusetts Chapter of the Society, was the moderator.

Q fever, thus far, has not been a problem in the New England area, but a significant incidence has been found in certain Western and Southwestern states, where the disease has been found in cattle, goats and sheep. According to studies of the disease, it is more resistant to heat than other organisms usually inactivated by pasteurization.

WISCONSIN

At the 10th meeting of the Wisconsin Section 108 members and guests heard Dr. Dack talk on "Problems of Food Poisoning." Dr. Dack gave an interesting talk enjoyed by all members of the Section, even though they represented a very diversified group of the food industries.

The April meeting was held at Ripon Foods Company, Ripon, Wisconsin with a tour of the plant and then dinner at the Republican House, the birthplace of the Republican Party. The speaker for the April meeting was Russell Maas, of Oscar Mayer and Company, who spoke on the "Fabrication and Utilization of Food Fats."

The May meeting combined the regular speaker-business meeting, with a Career Day at the University of Wisconsin. Members of the Wisconsin Section brought to the University prospective young high school students for a tour of the food technology facilities.

The Section appreciates the attendance it has had from people in the Chicago area. Our members were glad Miss Dorothy Huber was at our 10th meeting, for so many of us have been welcomed by her at the Chicago Section in the years past.

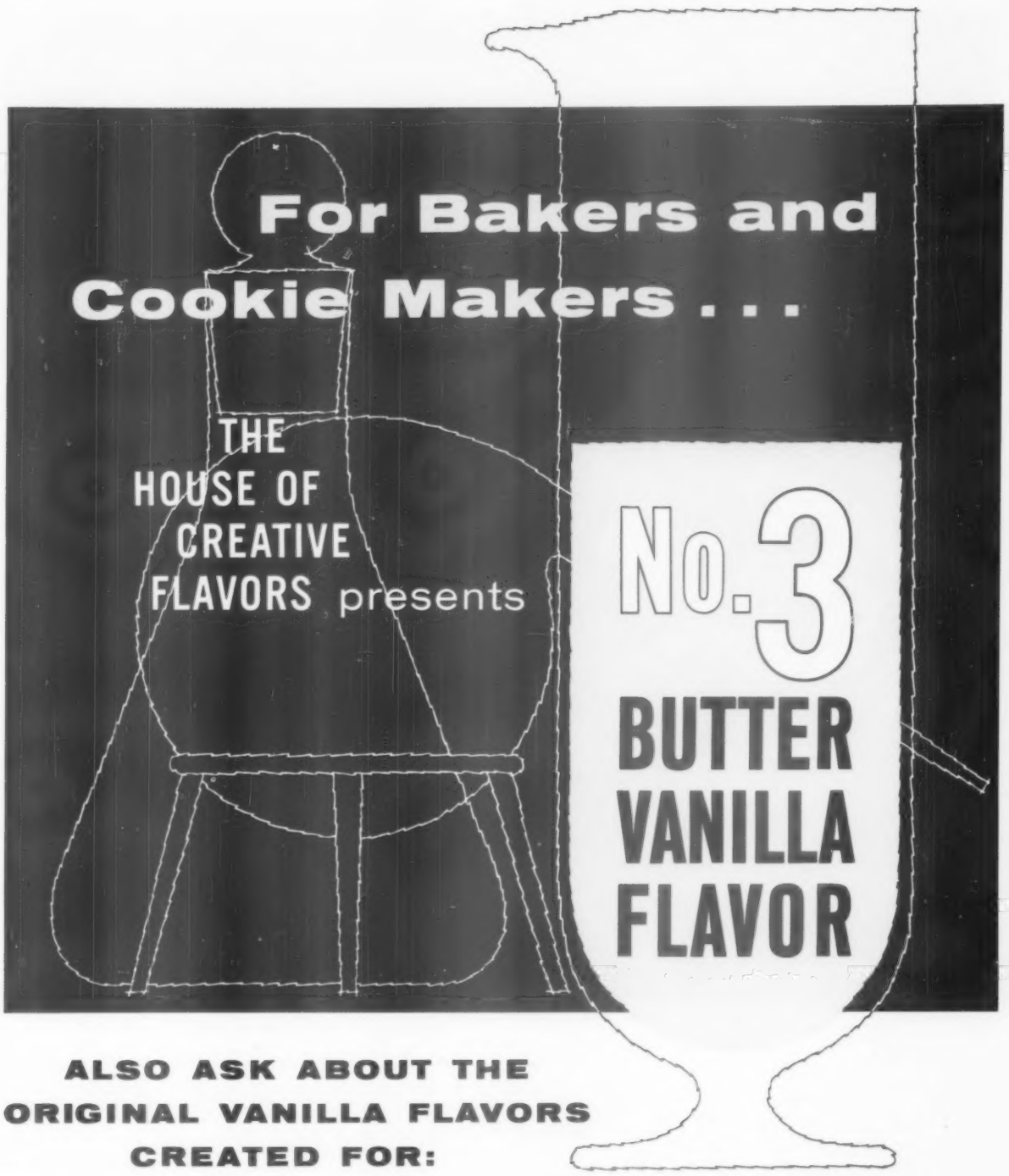
—Paul A. Buck

FUTURE MEETINGS FOR FOOD TECHNOLOGISTS

June 2–7	Eleventh Annual Industrial Microbiological Institute, Purdue University
June 8–12	Inter American Food Congress, Americana Hotel, Bal Harbor, Miami Beach, Florida. For information address J. Arthur Lewis, Box 954, South Miami 43, Florida
June 9–August 29	Gordon Research Conferences, Colby Junior College, New London, New Hampshire; New Hampton School, New Hampton; New Hampshire and Kimball Union Academy, Meriden, New Hampshire.
June 10–13	First International Congress on Vacuum Techniques, Namur, Belgium
June 12–13	First National Convention, Canadian Institute of Food Technology, Queen Elizabeth Hotel, Montreal. Theme: Canada's Food Industries
July 6–10	National Confectioners' Association 75th Annual Convention and Exposition, Sheraton-Palace Hotel, San Francisco, California
October 13–15	Association of Official Agricultural Chemists, Inc., Shoreham Hotel, Washington, D. C.
October 22–24	Fifth National Vacuum Symposium, American Vacuum Society, Sir Francis Drake Hotel, San Francisco, California

1959	
May 17–21	**Nineteenth Annual Meeting of the Institute of Food Technologists, Bellevue-Stratford Hotel, Philadelphia, Pennsylvania**
1960	
May 15–19	**Twentieth Annual Meeting of the Institute of Food Technologists, Civic Auditorium and Hotel Whitcomb, San Francisco, California**
1961	
May 7–11	**Twenty-first Annual Meeting of the Institute of Food Technologists, Hotel Statler, New York, New York**
1962	
June 17–20	**Twenty-second Annual Meeting of the Institute of Food Technologists, Americana Hotel, Bal Harbor, Miami Beach, Florida**

An open invitation is extended to readers of FOOD TECHNOLOGY Illinois notices of annual or national meetings of interest to food technologists. to send in to the Editorial Office, 11606 South Bell Avenue, Chicago 43,



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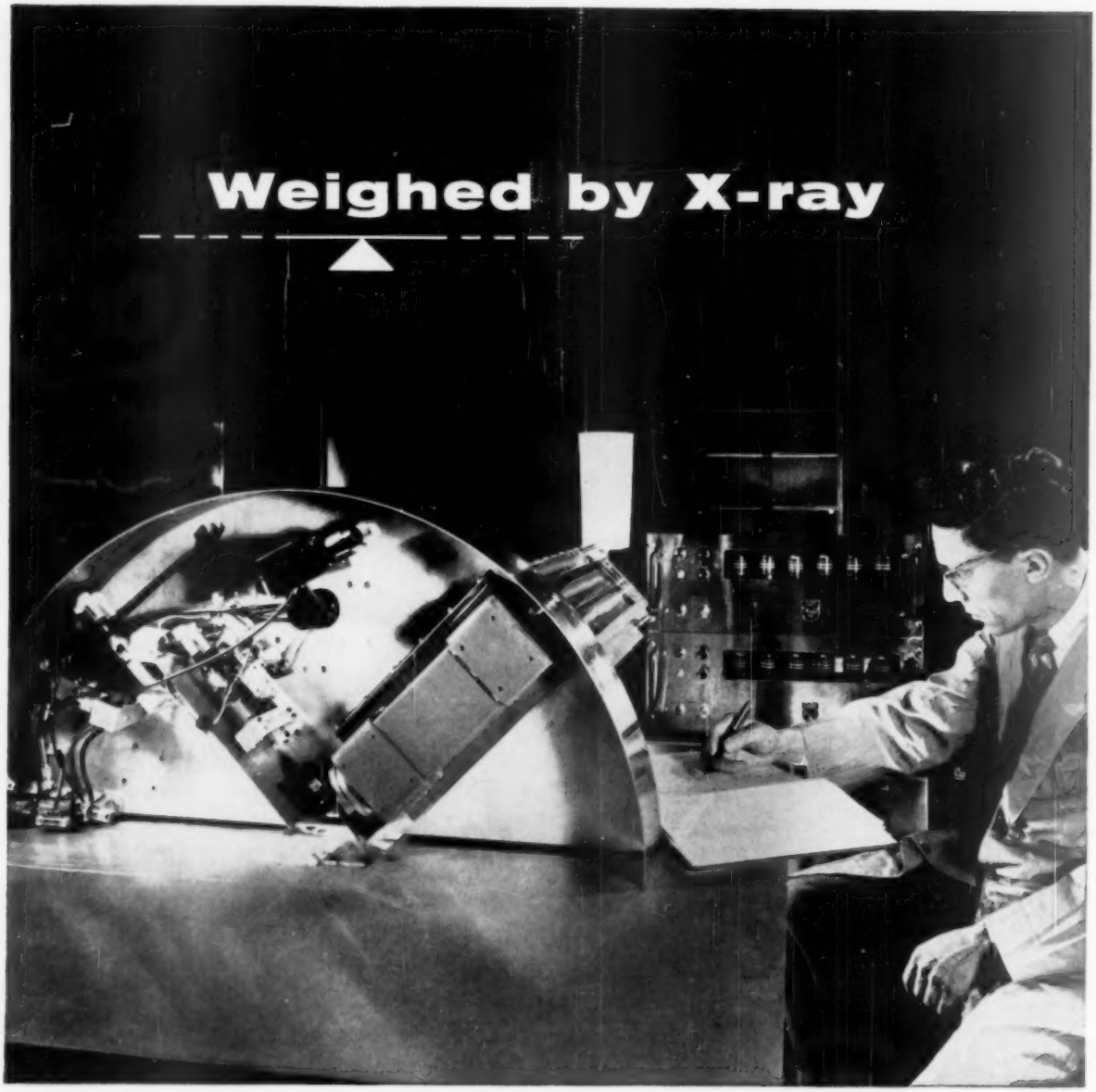

In making tinplate, the even distribution of tin over steel sheet is of prime importance. Varying thickness of coating would mean uneven protection for canned products. The X-ray tinplate gage shown above has proven an answer to this problem.

As rolls of shining tinplate speed from giant electrolytic tinning lines, samples are taken at regular intervals. Each sample is passed through the X-ray unit for measurement. Here, a beam of X-rays is directed at the tinplate. This radiation passes through the tin coating into the steel sheet, where the iron atoms are caused to fluoresce or emit new X-rays of their own. In passing back out through the tin coating, some of these fluorescent X-rays are absorbed. The thicker the tin is, the more X-rays are absorbed. By measuring the amount of fluorescent X-radiation above the sheet of tinplate with a Geiger counter, the thickness of the tin coating is determined.

Careful processing, typified by X-ray measurement, accounts for the consistently high quality of USS Tinplate . . . and for the expanding number of products protected by it. United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

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Tennessee Coal & Iron – Fairfield, Alabama
United States Steel Export Company

United States Steel

Literature

BOOKS

CHEMISTRY OF PLANTS. By Erston V. Miller. 174 pages. Reinhold Publishing Corp., New York, 1957.

The author's intention of emphasizing the chemistry of plants rather than the physiology has been fulfilled both interestingly and thoroughly.

Much more than that, however, he has displayed sensitive judgment in carrying the reader to just the right degree of completeness and complexity to provide appropriate emphasis for each of the twelve chapters.

The chapters themselves deal with carbohydrates, proteins, lipides, plant pigments, enzymes, organic acids, plant hormones, glycosides, alkaloids, vitamins, elemental constituents and a group of other plant products such as ethylene, some toxins and antibiotics.

The discussion of proteins and other nitrogen compounds (Chapter 2) advances adroitly to the frontiers of complexity and stops; avoiding digression from the main purpose of the book.

Each chapter begins with the origin or background of the subject, then advances to a discussion of the location, functions and importance of the lipid, plant pigment, enzyme, or other chapter subject.

The mechanisms of reactions are handled in part as structural formulas which are useful for learning comparisons and as lists or tables which have added value as ready references.

The distribution of the various plant substances in the plant as well as their ultimate value are given useful prominence.

Although the author has not stated it as a major purpose, this book could have been written specifically as a reference-text for food technologists.

Finally, the inclusion of the important references upon which the book is based, as well as a comprehensive index of both authors and subjects, makes this a book which the food technologist will find it worth while to possess.

ROBERT G. TISCHER
Chicago, Illinois

ADVANCES IN PROTEIN CHEMISTRY, Volume 12. Edited by C. B. Anfinsen, Jr., M. L. Anson, K. Bailey and J. T. Edsall. Academic Press Inc., Publishers, New York. 1957. x + 687 p.

The editors, with a stimulating and provocative preface, introduce the seven articles presenting significant advances in protein chemistry. H. A. Scheraga and M. Laskowski, Jr. describe in 131 pages the conversion of fibrinogen to fibrin under the influence of thrombin. This is not only an important contribution to a better understanding of blood clotting but also to our knowledge of the mechanism of conversion of an inactive precursor into a biologically active protein. The fibrinogen-fibrin conversion involves the conversion of prothrombin into thrombin and its action on fibrinogen. All aspects of this conversion are discussed by two active workers in this field who have published over 20 papers in this field since 1951. F. H. C. Crick and J. C. Kendrew discuss in 82 pages the important progress that has been made in X-ray studies of protein since this subject was reviewed in Advances in Protein Chemistry in 1945. Crick and Kendrew, after discussing the nature of X-ray diffraction, discuss its application to fibrous proteins, viruses and synthetic polypeptides. Of particular importance are the new methods involving heavy atoms which have proven most useful in unravelling the structure of crystalline proteins. H. A. Itano reviews the dramatic developments of recent years in the study of human hemoglobins and discusses the properties of both the normal and abnormal hemoglobins and their genetic control in 103 pages. C. H. Li continues his report on the hormones of the anterior pituitary gland which appeared in the preceding volume (11) by describing the melanocyte-stimulating and lactogenic hormones in 49 pages. H. Neurath reviews the recent development of our knowledge of the activation of zymogens with particular emphasis on the structural changes involved in forming an active enzyme from its inactive precursor. In the 68 page review he discusses the activation of trypsinogen, chymotrypsinogen, procarboxypeptidase and pepsinogen and the chemistry of their conversion into biologically active proteins (enzymes). H. C. Isliker, in 76 pages, reviews the chemistry of antibodies, showing the major advances in recent years in their purification both by physicochemical and immunochemical methods, and correlating their chemical properties with immunological specificity. In the final article, 173 pages, Mr. Goodman and G. W. Kenner discuss the synthesis of peptides, to bring the review presented in volume 5 of the Advances up to date. Of the ten contributors to the seven reviews, one is from Switzerland and three from England. Although all aspects of protein chemistry are important to the food scientist and technologist, the articles on fibrinogen-fibrin conversion, X-ray analysis and protein chemistry, and the activation of zymogens will be most useful. The food technologist is concerned with aspects of conversion of inactive to biologically active proteins as it applies to the preparation and use of proteolytic enzymes. Protein structure, particularly that of fibrous proteins like collagen, is important in understanding problems of texture.

M. A. JOSLYN
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Application of Peroxidase Test Paper in Food Processing[a]

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(Manuscript received November 2, 1957)

THE ENZYME most frequently used to evaluate the degree of blanching in food processing is peroxidase. Main reasons for its extensive use are (a) its presence in considerable amounts in practically all foods that require blanching, (b) its heat stability, which is of the right order, and (c) its activity, can be evaluated or measured conveniently by a number of methods *(1, 2, 3, 4, 6)*.

Some factors that influence the choice of a method for measuring peroxidase activity are amount of activity present, accuracy required, time available for a determination, adequacy of the facilities available, and experience of the worker in enzyme chemistry. For control work in food processing, some of these factors greatly out-weigh others. For example, blanched vegetables usually contain but small amounts of enzyme activity, facilities are rather limited in the control laboratories of many processors, and sometimes the technicians available for conducting the tests are not specialists. Yet, even with these conditions prevailing, it is frequently important to the food processor to have results of enzyme tests quickly. For a method to be satisfactory under such conditions, it should be simple, fast, require a minimum of apparatus, and yet furnish reliable results.

With this goal in mind, a peroxidase test paper *(5)* has recently been developed. The present study was undertaken to appraise the value of the test paper for measuring adequacy of blanching treatments in food processing.

MATERIALS AND METHODS

Preparation of test paper. The preparation and stability of the test paper have been described in detail elsewhere *(5)*. Briefly, fresh 1% alcoholic solutions of *o*-tolidine and urea peroxide are prepared. Immediately before use, equal volumes of these solutions are mixed to gixe a solution that contains 0.5% of each reagent. Filter paper is immersed in this solution just long enough to become completel saturated, then taken out, pressed to remove excess solution, and air dried. The prepared test paper is stored over a desiccant under refrigeration in the dark.

Use of test paper. The paper can be used in two ways. Small drops of vegetable extract are placed on the test paper, or the paper is touched with the moist surface of a piece of plant substance. When extracts are used, the time required for a blue color to appear is measured. This is done by starting a stop watch when the paper is moistened and stopping it when a definite reaction is observed. In order to make each test as impartial as possible the face of the stop watch was covered during the tests reported here. The extent of color formation selected as representing a positive reaction is, of course, somewhat arbitrary, but the same intensity of color was used in all tests insofar as possible. When extracts were used, the blue color usually appeared first along the outer edge of the moistened area.

If the moist surface of a piece of plant material, instead of an extract, is used for a test, the distribution of peroxidase within the tissue can be observed.

Evaluation. Masure and Campbell *(4)* have published a qualitative and a quantitative method with guaiacol as the substrate. The qualitative method is referred to as the U.S.D.A. method by some processors. It is fairly widely used for evaluating the peroxidase activity of blanched vegetables.

In order to compare the test paper with the Masure and Campbell methods, tests were made on extracts of several vegetables. For each vegetable, preparations with various levels of activity were prepared by two methods. Extracts of raw and of completely blanched material were mixed in different proportions, and other samples were blanched for different times. The extracts were prepared by blending one part of vegetable with 3 parts of distilled water in a Waring blender for 3 minutes and filtering through gauze-backed cotton milk filters.

Tests were made on all preparations by the Masure and Campbell qualitative method and the test paper. In addition, peroxidase activities were determined on some samples by the Masure and Campbell quantitative method. This method measures the rate of color formation after its initial appearance; hence it is not affected by the amount of reducing substances in the extract. Reducing substances influence only the time required for the initial appearance of color. Results of the quantitative method are expressed as increase in color density per minute, D/M, for 2 ml. of enzyme extract.

Blanching. The vegetables were cut, where necessary, into piece sizes comparable to those found in commercially frozen vegetables. The pieces of broccoli and asparagus, however, were cut somewhat shorter than commercial samples in order to fit them into the blanching apparatus.

The prepared vegetable sample was blanched in an open perforated aluminum basket that was placed in a Buchner funnel. Steam issuing from a second Buchner funnel was passed around and through the sample by lowering the funnel down over the basket. The steam-conducting funnel fitted inside the funnel that supports the basket containing the vegetable sample. The two funnels were preheated by steam before the vegetable sample was placed in position. This method of blanching has been used by the author for many years. Its efficiency has been established, in other studies, by comparing results obtained with it with results obtained with a semi-commercial-size steam blancher.

Preparations used in pH-optimum studies. In order to obtain preparations of the desired level of activity an extract of raw vegetable was mixed with an extract of the vegetable blanched sufficiently to destroy all peroxidase activity. To the various mixtures of vegetable extracts, appropriate buffers were added for purposes of adjusting their pH values. Following pH adjustment all preparations were made to the same volume with distilled water in order to maintain the same enzyme concentration in all dilutions. A final pH check of the dilutions was made with a pH meter using a glass electrode.

RESULTS AND DISCUSSION

Figure 1 shows the pH-activity curves for peroxidases of broccoli and cauliflower. It is quite apparent

[a] Presented at the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pennsylvania, May 12–16, 1957.

[b] Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

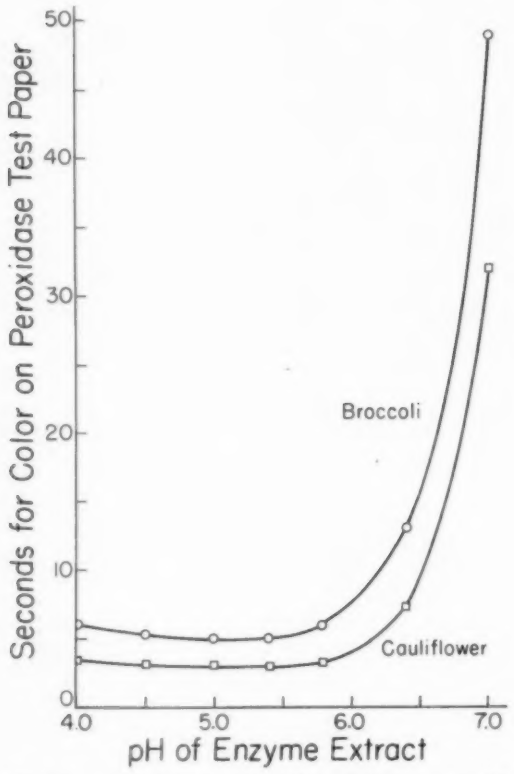

Figure 1. pH activity curves for broccoli and cauliflower peroxidases.

that for maximum paper sensitivity the test should be made between pH 4 and 6. However, since the paper appeared to be sensitive enough to be useful without pH adjustments the tests reported here were made on distilled water extracts without pH adjustments in order to simplify the procedure. They usually had pH values between 6.0 and 6.5.

Data for broccoli are summarized in Table 1, for cauliflower in Table 2, for asparagus in Table 3, and for peas in Table 4. These tables present results of the different test methods on preparations with various enzyme contents.

TABLE 1

Peroxidase activity of broccoli preparations by different test methods

Sample % raw[1]	Masure and Campbell		Peroxidase test paper	
	Qualitative	Quantitative	Seconds for color	Average
	3½ min. end point	D/M value		
1	Negative		75, 87, 77, 72, 75	75
2	Negative	11	40, 38, 39, 38, 37	38
3	Negative	20	24, 27, 25, 25, 27	26
4	Negative	28	16, 17, 18, 19, 19	18
5	Positive	42	13, 14, 13, 14, 14	14
10	Positive	100	6, 7, 8, 8, 6	7
Seconds blanched[2]				
30	Positive	39	10, 10, 10	10
45	Negative	17	21, 21, 21	21
60	Negative	15	32, 34, 33	33

[1] Samples prepared by mixing an extract of raw broccoli with an extract prepared from broccoli blanched sufficiently to inactivate peroxidase completely.
[2] In steam at 212° F.

TABLE 2

Peroxidadse activity of cauliflower preparations by different test methods

Sample % raw[1]	Masure and Campbell		Peroxidase test paper	
	Qualitative	Quantitative	Seconds for color	Average
	3½ min. end point	D/M value		
1	Negative	12	136, 138, 142, 140, 150	141
2	Negative	29	83, 83, 80, 78, 81	81
3	Positive	32	57, 67, 55, 50, 55	57
4	Positive	54	45, 50, 45, 46, 52	48
5	Positive	67	40, 38, 37, 38, 43	39
10	Positive	171	18, 20, 19, 17, 17	18
Minutes blanched[2]				
1	Positive		10, 11, 10, 9, 10	10
2	Positive		15, 14, 14, 16, 15	15
3	Positive		20, 19, 21, 20, 18	20
4	Negative		57, 57, 61, 65, 64	61

[1] Samples prepared by mixing an extract of raw cauliflower with an extract prepared from cauliflower blanched sufficiently to inactivate peroxidase completely.
[2] In steam at 212° F.

TABLE 3

Peroxidase activity of asparagus preparations by different test methods

Sample % raw[2]	Masure and Campbell		Peroxidase test paper	
	Qualitative	Quantitative	Seconds for color	Average
	3½ min. end point	D/M value		
10	Negative		61, 54, 61, 59, 65	60
20	Negative		29, 32, 35, 29, 32	31
30	Negative		27, 22, 22, 27, 25	25
40	Positive		20, 20, 24, 21, 21	21
50	Positive	16	18, 18, 17, 15, 15	17
100	Positive	36	6, 5, 6, 6, 6	6
Seconds blanched[2]				
30	Negative		49, 43, 41, 52, 50	46
60	Negative		>180	

[1] Samples prepared by mixing an extract of raw asparagus with an extract prepared from asparagus blanched sufficiently to inactivate peroxidase completely.
[2] In steam at 212° F.

It was found that a significant amount of peroxidase activity is required to give a positive reaction by the Masure and Campbell qualitative test. For example, 4% of the activity of raw broccoli gave a negative test in the 3½-minute observation time which is standard for this method. This level of activity is readily measurable, however, by the Masure and Campbell quantitative method, and it also gives a strong positive reaction on the test paper. The paper is quite sensitive to the amount of peroxidase in samples of most vegetables that have been given a minimum acceptable blanching treatment according to the qualitative Masure and Campbell test.

For a given vegetable, relative activities of samples containing known amounts of raw extract were as accurately determined by the test paper as by the Masure and Campbell quantitative method. The test paper, however, was less sensitive to cauliflower peroxidase, for an equivalent level of activity as judged by D/M values, than to the peroxidases of peas and broccoli. Two factors may be responsible for this observed reduced sensitivity: pH of the extract and amount of reducing substances present. The method for D/M values, which measures rate of color formation after its initial appearance, is not affected by the

TABLE 4

Peroxidase activity of pea preparations by different test methods

Sample % raw[1]	Masure and Campbell		Peroxidase test paper	
	Qualitative	Quantitative	Second for color	Average
	3½ min. end point	D/M value		
2	Negative		91, 112, 103, 127, 95	106
4	Positive		57, 60, 46, 57, 50	54
8	Positive	30	22, 24, 26, 25, 25	24
10	Positive	34	19, 20, 23, 22, 21	21
Seconds blanched[2]				
30	Positive	207	12, 14, 13, 13, 12	13
40	Positive	10	45, 43, 46, 49, 45	46
45	Negative		180	

[1] Samples prepared by mixing an extract of raw peas with an extract prepared from peas blanched sufficiently to inactivate peroxidase completely.

[2] In steam at 212° F.

amount of reducing substances in the extract, but the time for color on the test paper is increased by increasing amounts of reducing substances. Test paper sensitivity also varies with the pH of the extract, but in the method for D/M values the pH is controlled. The Masure and Campbell qualitative method is similar to the test paper method in that it too is affected by pH and the presence of reducing substances. Since these factors are fairly constant for a given vegetable, they may be tolerated for qualitative work where it is desirable to have a very simple procedure. However, they should be kept in mind when one tries to compare data for different vegetables.

Variation in times for color on the test paper due to differences in pH values could, of course, be controlled. By adjusting the extracts to pH 5, the time for color on the test paper would offer a good index of relative peroxidase activities of different vegetables. In testing for an adequate blanch a procedure involving pH control of the extracts would make it possible to establish a more nearly standard time for color on the test paper. The advantages of a simple procedure sacrifice the gains to be had by more precise, involved procedures.

Having once established the time required for a positive reaction on the test paper, with extracts of acceptably blanched samples of a particular vegetable, the test paper offers a very convenient means of routinely checking additional samples to determine how they compare with the established value.

Asparagus contained so little peroxidase, shown by all 3 methods, that it may not be the enzyme of choice for evaluating the blanching treatment for this vegetable. Further work in this area appears to be indicated.

At present, no attempt has been made to suggest a tolerance or time for color on the test paper to indicate adequately blanched vegetables. It is probably premature to make recommendations based on blanching conditions used experimentally for only one lot of each vegetable. Realizing the limitations, however, it can be stated that samples of all vegetable that required more than one minute for color to appear on the paper were adequately blanched as judged by results of the qualitative Masure and Campbell test on the same samples.

Extracts of vegetables were used for this study, since only in this way could the test paper be compared with the Masure and Campbell methods. The paper can be used advantageously, however, without preparing extracts. For example, quick tests have been made on individual pieces of vegetable obtained directly from blanchers in processing plants. Large pieces of cauliflower and broccoli were taken as they emerged from the blanchers and a freshly cut surface was touched to the test paper. It was revealed that the center portions contained significant amounts of peroxidase activity although when the same pieces were used to prepare extracts, the material was found to be adequately blanched by accepted standards.

In addition to the work on vegetables a few experiments were done with the test paper to detect milk peroxidase. By buffering milk to pH 5, and adding a small amount of salt, peroxidase activity was readily detected in samples of commercially pasteurized milk. Results of these exploratory experiments indicate that the test paper can be used to detect milk products that have received heat treatment in excess of that required for pasteurization.

SUMMARY

A study has been made to appraise the value of a test paper for measuring the peroxidase activity of blanched vegetables. Results given by the test paper are compared with results of the Masure and Campbell qualitative and quantitative methods. The study indicates that the test papers offer food processors a convenient means of evaluating peroxidase activity of food samples.

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Moisture Migration in Frozen Canned Bread[a]

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(Manuscript received October 4, 1957)

THE CHIEF ADVANTAGE in freezing preservation of bread is that the rate of staling is greatly reduced, and when held at a temperature as low as −30° F., the bread remains palatable for about a year. Bread in military rations is packed under vacuum in tin cans and should have a shelf life of several years at 0° F. or lower. Some research workers have reported that not only was staling practically stopped by freezing but also after being frozen for 60–70 days, refreshening was observed. Generally, bread removed from the freezer staled at about the same rate as did unfrozen bread *(4)*.

The moisture content of freshly baked bread varies in different parts of the loaf, and migration of moisture alters the quality of the bread. Bice and Geddes *(1)* found that the crust, outer crumb, and inner crumb of freshly baked bread contained 15.4, 44.9, and 45.1% moisture, respectively. Pence *et al. (2)* agreed with previous workers that moisture in freshly baked bread moved outward from the outer crumb to the crust, and that there was a slow decrease in moisture of the inner crumb. They reported that the moisture distribution in frozen freshly baked bread remained essentially the same as that of unfrozen freshly baked bread. A very slight increase in moisture occurred in the crust and outer inch of crumb as a result of freezing, but this increased moisture gradually disappeared during storage. The distribution of moisture in frozen-and-defrosted bread was likewise essentially like that of the unfrozen.

Pence *et al. (3)* also reported that bread held for 10 weeks at 0° F. developed a whitened ring from ⅛ to ¼ inches wide lying from ⅛ to ⅜ inches beneath the crust surface. This "freezer burn" was thought to result from movement of moisture by sublimation within relatively narrow regions. Reversion to the natural appearance did not occur on defrosting or on refreshening by heating to 140° F. for a few minutes. But moistening the whitened crumb and allowing it to dry, or exposing it to a humid atmosphere for a day or two restored the normal appearance.

EXPERIMENTAL RESULTS

In the course of a 5-year study of the stability of military rations, under semi-commercial conditions, (in a room 6 x 8 x 8 ft. with a unit cooler and the fan operating about 80% of the time) it has been found that there was a steady movement of moisture from one side of cans of frozen bread to the opposite side, when held at 0° F. or lower. After 18 months, the quality of the frozen bread was drastically changed in texture and flavor, to such an extent, in fact, that it was unacceptable to the taste panel. Nine-ounce cans of bread stored at −20° F. for 24 months accumulated 1.6 ounces of ice, which was 17.7% of the original weight of the bread.

The first evidence of moisture migration was observed after about 12 months' storage at −20° F. when it was determined that the texture and moisture content of the bread varied widely in different locations within the cans. Bread in cans removed after 18 months' storage was very dry, hard, and severely shrunken on one side of the can and moist on the other side. Figure 1 (20 months' storage) portrays the effects.

Figure 1. Migration of moisture in frozen canned bread. (Left) Can of bread stored at −20° F. for 20 months, showing how moisture migrated to the far side of the can and accumulated as ice. (Center) Loaf of hard, dry, shrunken bread removed from 9-ounce can, together with 42 ml. of water from melted ice. (Right) Can of bread.

Bread stored for 24 months and opened immediately, contained a mass of ice more than one-fourth inch thick, extending about one-third around the interior of the can and as high as the loaf of bread. Cans of frozen bread were opened, the ice removed, and the moisture content of the bread in several sections of the cans was determined. The bread on the side of the can closest to the refrigeration coil contained 29.1% moisture, that in the center of the cans contained 25.0%, and that on the opposite side contained 23.0% moisture.

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The moisture in the bread did not equilibrate in unopened cans held at 70° F. for 5 days. When the cans were held in an upright position, the upper third of the loaves of bread contained 26.8% moisture and was very hard and dry; the middle third contained 30.3% moisture and was quite stale; while the lower third contained 45.0% moisture and was very soggy with an objectionable yeasty flavor.

There was no difference in the pH of the frozen or thawed bread in different locations within the cans. Readings in 4 widely different parts of loaves of bread were from pH 4.7 to 4.75. The "ice water," immediately after thawing in the unopened cans, was found to have a pH reading of 5.5 to 6.7. It contained about 3% soluble solids, a considerable portion of which was reducing (fermentable) sugars.

The cans of bread when stored had a vacuum of 26.9 inches. During 30 months in storage (a) the vacuum gradually dropped to about 24 inches and (b) the peroxide values of the fat of the bread dropped from 5.4 me/kg. to about 3.8 me/kg. There were no significant changes in riboflavin, niacin, thiamine, or total acidity.

DISCUSSION

Conditions associated with the migration of a relatively large quantity of moisture in frozen bread were: (a) the bread was in hermetically sealed containers; (b) the storage period was 12 months or longer; (c) the packages remained in the same position during storage, with respect to the direction of heat flow; (d) fluctuations in the storage temperatures were similar to those in commercial warehouses; (e) the bread was very porous and relatively free of sugars and other hygroscopic materials; (f) migration of moisture was continuous for more than 30 months; and (g) there was a relatively high temperature gradient from one side of the can to the other.

Accumulated effects of migration of a relatively large quantity of moisture in frozen bread were: (a) when the bread was allowed to thaw in the unopened cans it was unacceptable to the taste panel because one side of each loaf was too dry, shrunken, hard, and tasteless, whereas the other side was too moist and soft; (b) when the bread was removed from the cans in the frozen state, the palatability could be restored by slicing, moistening, and placing in a bread warmer at 140° F. for 10 minutes; (c) due to the slowness of the redistribution of moisture, bread thawed in the cans became practically worthless.

Moisture in the amount of almost one-fifth of the weight of the frozen bread may migrate to one side of the can and accumulate as ice. Upon thawing, the lower portion of the loaves may contain more than 45 per cent moisture after standing at room temperature for as long as five days.

RECOMMENDATIONS

To minimize the problems of moisture migration in frozen canned bread held for more than nine months, it is recommended that (a) the position of the cans of frozen bread be changed every 6 months, (b) the bread be removed from the cans before thawing, and (c) a satisfactory means of moistening and heating be provided for redistribution of moisture in the bread.

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Microwave Sublimation of Foods

(Manuscript received November 27, 1957)

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THE THEORETICAL BASIS for microwave freeze-drying can best be described by reference to the dielectric losses involved. In this paper, the equipment will be briefly described and then, with this clearly in mind, increasing loads will be shown to improve efficiency. Drying cycle curves will be presented as well as the effect of increasing rates of microwave energy input on the freeze-drying cycle.

There are three basic advantages in using microwave energy as employed in the process to be described in comparison with other uses of microwave heat and with conventional freeze-drying: Microwave energy when used in defrosting procedures for frozen foods presents the problem of heating water in both the frozen and thawed states which is not encountered in the present application. In the case of heating thawed material, the penetration of microwave energy into food substances is limited to a few inches *(1)*; but into ice, on the other hand, much greater penetration is obtained. When freeze-dried foods are heated in the conventional process, as on warm shelves, the heat required may damage the dried material. However, in microwave freeze-drying no contact with the heated surface is required, and the periphery of the food which is already dried does not heat. Tappel and coauthors *(4)* have reported drying cycles of about 24 hours using the conventional heat supply for freeze-drying meat. The present report is concerned with the application of microwave energy at 2450 mc. to improve the sublimation rate.

EXPERIMENTAL

Figure 1, a diagrammatic description of the equipment used in our tests, indicates the relationship of the microwave heated still or sublimator to refrigerated condenser and vacuum pump. Pre-frozen food is loaded into the still after the condenser coils are down to −30° to −40° C. The vacuum pump is started. When operating pressure is reached, the radio-frequency circuit is closed and energy applied at a predetermined rate. Evolved water vapor is collected on the refrigerated coils and noncondensable gases eliminated by the vacuum pump. Trial runs serve to establish the drying cycle, and the product is considered dry when the moisture level is 3% or less. The latent heat of sublimation for ice may be taken as approximately 670 calories per gram under our operating conditions. In microwave freeze-drying this heat is generated within the frozen part of the food and conducted to the ice-vapor interface according to the ΔT established by ice heating and interfacial evaporative cooling. Recession of residual ice into the interior of the drying food does not interfere with the continued supply of sublimation heat as shown in Table 1 and the drying curves presented below.

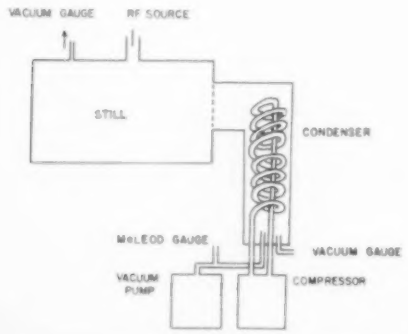

Figure 1. Freeze-drying apparatus employing high frequency energy at 2450 mc. as the source of heat sublimation.

Total operating pressures range from 0.5 to 1 mm. The product remains frozen until all the ice has sublimed. Then, as the process nears completion, the dried food rises to room temperature or slightly higher. The prepared product is packaged in glass in an inert atmosphere for further evaluation.

Product analyses included rehydration and flavor evaluations in conjunction with 100° F. (accelerated) and room temperature storage.

RESULTS AND DISCUSSION

Table 1 shows that the dielectric properties of water at 2450 mc., as measured by its dielectric constant and loss tangent, mark water as the most vigorous absorbing material in the list for microwaves. Its loss factor is 865 times that of ice as shown in the third column *(5)*. Thus, with water and ice present in a microwave field, the water would absorb energy selectively at the expense of the ice. In freeze-drying then, microwaves are absorbed by ice with no water present, since the material is maintained in a frozen state by evaporative cooling at the low pressures involved. Now, consider the loss factor for dried sirloin. This factor, which is in this instance an estimate made from comparative heating tests, is less than a third that of ice. When dried, the food becomes much less receptive to the energy, which should lessen the danger of overheating and provide intrinsic control of drying. The next theoretical advantage occurs in connection with penetration of microwave energy into ice. The last column of Table 1 shows that the penetration of microwave

TABLE 1

Dielectric constants and loss tangents of various materials at 2450 mc.

Material	DC	Tan $\delta \times 10^4$	Loss factor	Half power depth[3] (cm.)
Water (1.5° C.)	80.5	3100	2.45×10^5	0.7
Water (25° C.)	76.7	1570	1.21×10^5	1.25
0.1 M NaCl (25° C.)	75.5	2400	1.82×10^5	0.8
Ice (−12° C.)	3.2	9	28.8	700.0
Suet (25° C.)	2.5	700	1750	12.0
Steak[1] (25° C.)	40.0	3000	1.20×10^5	
Dried Sirloin (25° C.)			9.6[2]	
Pyres (25° C.)	4.82	54	260.0	

[1] Bottom round steak.
[2] Assumed value based on tests which indicated that frozen beef absorbed 3 times more energy than dried beef.
[3] Calculated depth at which the initial power has decreased to one-half.

energy into ice as calculated by the half power depth is about 1,000 times greater into ice than into water *(3)*.

Figure 2 shows the decrease in weight with microwave freeze-drying time for 1 in. thick rib steaks. The heat requirement for the sublimation of ice involved in this case is:

$$2240 \text{ g. x } 0.78 \frac{\text{watt hours}}{\text{g.}} = 1748 \text{ watt hours,}$$

where 2240 is the weight of ice sublimed and 0.78 is the sublimation energy requirement.

The microwave power level by standard calorimetric test using one liter of water was 350 w. Thus, over the 3.2 hour duty cycle the energy used was:

$$350 \text{ x } 3.2 = 1120 \text{ watt hours.}$$

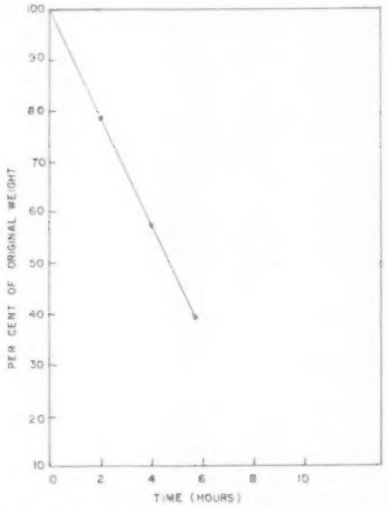

Figure 2. Drying curve for 1" thick rib steaks using high frequency energy at 2450 mc.

From Figure 3, the microwave energy may be corrected for the present load as follows:

$$\frac{1.75}{1.58} \text{ x } 1120 = 1240 \text{ watt hours,}$$

where 1.58 kw. is the power on a calorimetric test result using a one liter water load and 1.75 kw. is the power level indicative of a load of 2240 g. Since power measurements with frozen material also show an approximately 20% greater absorption in other tests (microwave power absorption was compared by heating frozen and thawed meat) carried out in our laboratories:

$1240 + 20\% = 1488$ watt hours microwave energy.

The required energy is supplied within 15% by microwaves in this case of a properly loaded radio-frequency energy source. The power per unit weight of ice sublimed $\frac{\text{(microwave power input to freeze-drier)}}{\text{wt. of ice}}$ therefore diminishes as the food load increases. The energy not supplied by microwaves may be accounted for by the equipment ambient.

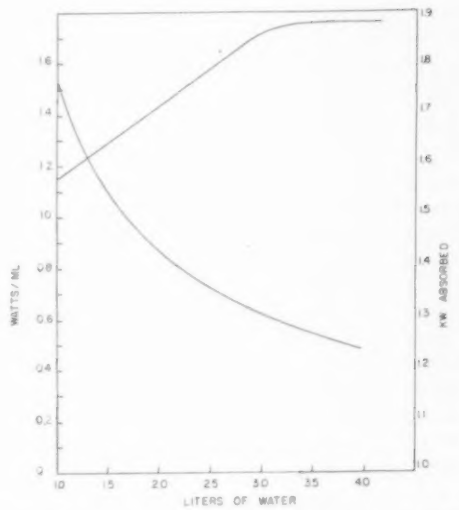

Figure 3. The effect of increasing water load on power measurements at 2450 mc.

Figure 4 presents data for smaller loads of beef which show less linearity due to the smaller load (especially during the terminal phase of freeze-drying) as well as the comparative effect of using the equipment without microwaves *(2)*.

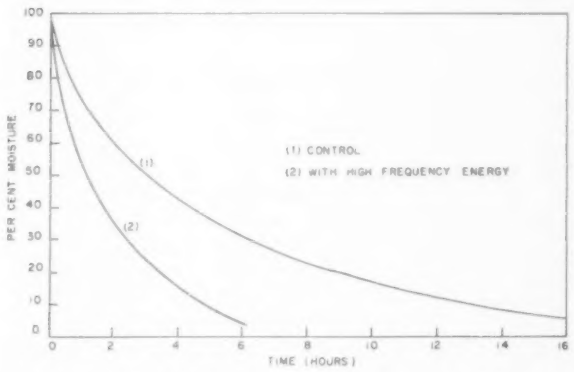

Figure 4. Freeze-drying curves for beef sticks dried with and without the use of high frequency energy at 2450 mc.

Keeping the drying conditions as nearly constant as possible, and taking the same initial load at time zero but varying the rate of heat energy input, yields the increased sublimation rate shown in Table 2. These data are obtained from shrimp drying cycles where in all cases energy input was insufficient to cause thermal product damage.

TABLE 2

The effect of increased microwave power on sublimation rate

Cycle hour	Microwave watts	Grams sublimed
1	300	431
2	480	522
3	600	726

In practically all cases, microwave freeze-dried foods rehydrated well and rated high in flavor evaluations. Storage tests at various temperatures are being conducted.

SUMMARY

Some of the operating conditions for microwave sublimation of foods have been examined. Electrical loss factor differences between water and ice indicate that for the all ice system an orderly process for the addition of sublimation energy to ice occurs. The interaction of the energy with the ice when dried food is also present indicates a selective heating of the ice portion which contributes intrinsic control in the drying process. As a consequence of the loss factor for ice, penetration of the energy in depth is much greater than in the case of water so that adequate heating is provided within the ice phase. Reduction in drying cycles by 75% over the conventional heating time was demonstrated. The energy required by the sublimation process was accounted for by the factors for increased microwave energy effects with larger loads and with ice. Sublimation rates were shown to be directly related to the microwave energy supplied.

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Colorimetry of Baby Foods[a]

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(Manuscript received November 27, 1957)

COLOR, AN IMPORTANT FACTOR in the quality and acceptability of most foods, is of particular importance in determining the consumer acceptance of glass packed baby foods. Not only must these products possess appealing colors, but there must also be a uniformity and constancy of color if the housewife's confidence is to be maintained.

Insuring such uniformity is dependent upon the availability of adequate means of measuring and specifying the color of baby foods. The advent in recent years of various new colorimetric instruments capable of determining diffuse reflectance has made the task of assaying the color of opaque foods objectively, a relatively simple matter. The choice of instrument would be largely based upon such factors as type of measurement selected (whether spectral reflectance or color difference), desired accuracy, ease and speed of manipulation, adaptability of instrument to other types of color measurement (i.e. general utility) and, of course, cost. It was the purpose of the present study to evaluate several commonly used colorimetric instruments as tools for the measurement of color in fruit and vegetable baby food purées.

The existence of numerous means of expressing color data (such as Munsell values, color dictionary references, C.I.E. designations, Hunter values, etc.) makes it possible to carry out colorimetric comparisons of samples by a variety of means. Most instruments however are designed for a particular mode of color designation, though conversion of data from one system to another can usually be carried out by calculation, reference to a nomograph or through the use of automatic integrators.

The one color specification system now generally recognized as the fundamental one is that proposed in 1931 by the Commission Internationale d'Éclairage (International Commission on Illumination) *(1)*. For this reason, the various data obtained in this study were converted into C.I.E. values to permit comparison.

EXPERIMENTAL

Four common colorimetric instruments adaptable to the measurement of color of opaque samples were used in the present study. They were:

(1) A Beckman DU Spectrophotometer[b] equipped with a reflectance attachment calibrated using a Bureau of Standards Vitrolite plate. Since this was the only one of the instruments utilizing a NBS calibrated standard, and since the accuracy of the Beckman spectrophotometer is generally acknowledged, it was considered as the "reference" instrument.

(2) An American Optical Rapid Scanning Spectrophotometer,[c] equipped with a reflectance attachment and calibrated with a white Carrara plate.

(3) A Gardner Color and Color Difference Meter,[d] calibrated using the color tiles most closely resembling the color of the products.

(4) A Photovolt Model 610 Reflection Meter,[e] calibrated with a white enamel standard.

The X, Y, Z values of the samples were computed from the Beckman and American Optical spectral reflectance data using the ten selected ordinate for Standard Source A *(1)*; with the Gardner meter by computing them from the a, b and Rd values using a nomograph, and with the Photovolt Reflection meter by using the proper tristimulus filter and calculations. Products tested were commercially prepared strained apples, beets, carrots, green beans, peaches, pears, peas and spinach provided by a baby food packer. Two analysts conducted all the measurement individually and at different times. All measurements were carried out in duplicate except for those made with the Beckman Spectrophotometer where a single measurement was run by each analyst. Thus, in all cases data in quadruplicate were obtained on each product for each instrument, except for the Beckman where only duplicate data were obtained.

RESULTS AND DISCUSSION

The data are summarized and analyzed in Tables 1, 2 and 3 and illustrated in Figure 1. It is apparent from Table 2, that for the X, Z, x and y values, the American Optical Spectrophotometer most closely approximated the Beckman Spectrophotometer while the Photovolt differed most from the Beckman in the Z, x and y values. For the Y value, the Photovolt Reflectometer gave the least variation from the Beckman Spectrophotometer and the Gardner Meter the most. The Gardner also gave the greatest variation for the X value.

The analysis of variance of the data, summarized in Table 3, showed that the deviation from the Beckman of the X values was not the same for all types of products. In other words, the amount by which the three other machines deviated from the Beckman for the X value was not the same for all products. However, there was no such significant difference among products for the Y and Z values. The instruments themselves were shown to influence the deviation occurring in the Z values but not in the X and Y. This is the most important of the main effects and might be due to the fact that since the Z values were all rela-

[a] Contribution No. 1082 of the University of Massachusetts, College of Agriculture Experiment Station, Amherst, Mass.

[b] Manufactured by Beckman Instruments Inc., Fullerton, Calif.

[c] Manufactured by the American Optical Co., Buffalo 15, N. Y.

[d] Manufactured by Gardner Laboratory, Inc., Bethesda 14, Md.

[e] Manufactured by the Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

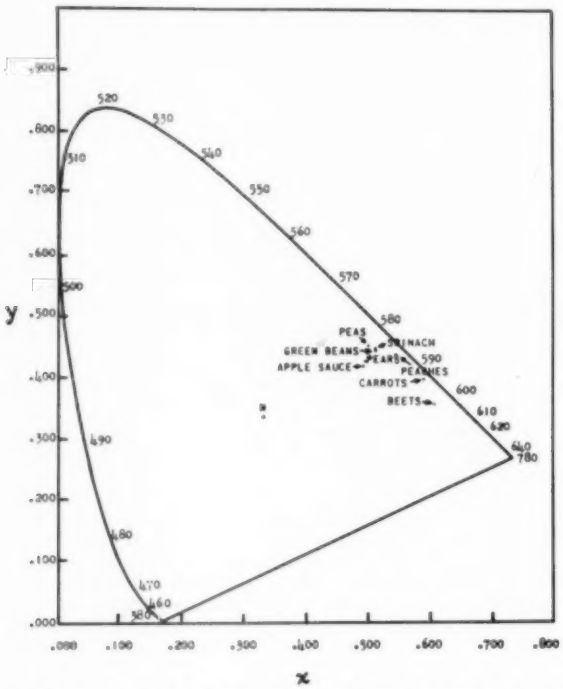

Figure 1. C.I.E. trichromaticity diagram, showing a) the locus of spectral colors, b) the location of the neutral point (N), and c) the location of the chromaticity coordinates of the baby foods tested, as determined using the Beckman model DU spectrophotometer with reflectance attachment.

tively low (no blue products were used) the errors in reading the instruments and in subsequent computation became correspondingly great. The observer effects were not significant. Curiously enough, significant interactions were observed for the product-instrument, product-observer, and instrument-observer relationship.

It may therefore be inferred that a single observer, working with a single instrument on a single product, will obtain reproducible data. In spite of this, different observers, working with different products but the same instrument, or different observers, with different instruments but the same product, as well as the same observer working with different products and different instruments, will not obtain readings which are consistent with the Beckman. This means that different observers observe different results on the same product depending upon the instrument which they are using; different observers using the same instrument get different readings depending upon the product they are observing, and that the same observer will show different readings among products depending on the instrument he is using.

The possibility that different observers do not get uniform results with different products when using the Beckman was not analyzed. However, inspection of the data showed a much closer agreement between readings obtained by the observers, than between Beckman readings and readings of other instruments. The lack of reproducibility with the Beckman of the other instrument may not always be of great practical

TABLE 1

Tristimulus values and trichromaticity coordinates of baby foods as measured by four colorimetric instruments

Product	Instrument	X	Y	Z	x	y
Apple Sauce	Beckman	0.178	0.150	0.033	0.493	0.416
Apple Sauce	Am. Optical	0.130	0.123	0.034	0.453	0.429
Apple Sauce	Gardner	0.141	0.136	0.093	0.382	0.368
Apple Sauce	Photovolt	0.169	0.149	0.190	0.333	0.293
Beets	Beckman	0.046	0.027	0.003	0.608	0.354
Beets	Am. Optical	0.046	0.023	0.003	0.638	0.323
Beets	Gardner	0.036	0.017	0.007	0.605	0.277
Beets	Photovolt	0.037	0.022	0.022	0.455	0.272
Carrots	Beckman	0.230	0.153	0.005	0.592	0.395
Carrots	Am. Optical	0.210	0.158	0.008	0.559	0.420
Carrots	Gardner	0.175	0.121	0.017	0.559	0.386
Carrots	Photovolt	0.165	0.124	0.046	0.493	0.370
Green Beans	Beckman	0.140	0.120	0.013	0.512	0.440
Green Beans	Am. Optical	0.121	0.110	0.020	0.482	0.438
Green Beans	Gardner	0.110	0.106	0.035	0.440	0.422
Green Beans	Photovolt	0.100	0.108	0.041	0.403	0.432
Peaches	Beckman	0.231	0.183	0.009	0.546	0.433
Peaches	Am. Optical	0.202	0.164	0.011	0.536	0.435
Peaches	Gardner	0.184	0.165	0.020	0.499	0.446
Peaches	Photovolt	0.191	0.171	0.106	0.407	0.366
Pears	Beckman	0.241	0.205	0.040	0.496	0.422
Pears	Am. Optical	0.212	0.184	0.039	0.487	0.423
Pears	Gardner	0.199	0.204	0.113	0.385	0.397
Pears	Photovolt	0.204	0.203	0.175	0.351	0.348
Peas	Beckman	0.277	0.247	0.027	0.502	0.449
Peas	Am. Optical	0.244	0.219	0.038	0.486	0.437
Peas	Gardner	0.204	0.210	0.072	0.420	0.432
Peas	Photovolt	0.202	0.211	0.073	0.415	0.434
Spinach	Beckman	0.057	0.049	0.005	0.513	0.443
Spinach	Am. Optical	0.050	0.038	0.010	0.509	0.390
Spinach	Gardner	0.039	0.039	0.006	0.462	0.461
Spinach	Photovolt	0.038	0.040	0.012	0.421	0.446

TABLE 2

Deviations of tristimulus values and trichromaticity coordinates of baby foods, measured using the American Optical, Gardner and Photovolt instruments, from corresponding data obtained with the Beckman spectrophotometer

Product	Deviation from Beckman values														
	American Optical					Gardner					Photovolt				
	X	Y	Z	x	y	X	Y	Z	x	y	X	Y	Z	x	y
Apple Sauce	.048	.027	.001	.040	.013	.037	.014	.060	.111	.048	.009	.001	.157	.160	.123
Beets	0	.004	0	.030	.011	.010	.010	.004	.003	.077	.009	.005	.019	.153	.082
Carrots	.020	.005	.003	.033	.025	.055	.032	.012	.033	.009	.065	.029	.041	.099	.025
Green Beans	.019	.010	.007	.030	.002	.030	.014	.022	.072	.018	.040	.012	.028	.109	.008
Peaches	.029	.019	.002	.010	.002	.047	.018	.011	.047	.013	.040	.012	.097	.139	.067
Pears	.029	.021	.001	.009	.001	.042	.001	.073	.111	.025	.037	.002	.135	.145	.074
Peas	.033	.028	.011	.016	.012	.073	.037	.045	.082	.017	.075	.036	.046	.087	.015
Spinach	.007	.011	.005	.004	.053	.018	.010	.001	.051	.082	.019	.009	.007	.092	.003
% Average deviation for all products	13.1	11.3	23.8	4.1	3.6	22.3	12.1	173	12.0	8.6	21.1	9.2	393	23.1	11.9

TABLE 3

Analysis of variance on deviations of tristimulus values of baby foods computed from data obtained using the American Optical, Gardner, and Photovolt instruments from corresponding values determined using the Beckman spectrophotometer

Source	Degrees of freedom	Least significant difference		X		Y		Z	
		5%	1%	Mean square	F ratio	Mean square	F ratio	Mean square	F ratio
Total variation	95								
Product	7	2.49	3.65	0.0035	3.54*	0.0013	1.22*	0.0078	1.81*
Instrument	2	3.63	6.23	0.0025	0.96*	0.0004	0.31*	0.0328	5.85*
Observer	1	5.12	10.56	0.006	3.14*	0.0002	0.22*	0.0002	0.95*
Product x instrument	14	1.86	2.40	0.0008	8.66	0.0006	25.2	0.0039	97.5
Product x observer	7	2.16	2.94	0.0003	3.33	0.0005	22.0	0.00046	11.5
Instrument x observer	2	3.15	4.98	0.002	22.2	0.0006	23.0	0.0017	41.5
Errors	62			0.00009		0.00002		0.00004	

* F values were determined using the interaction mean square as the error term since the interactions were significant *(4)*.

importance to a food packer, since he could set up his own colorimetric standards for this quality control program. It does indicate that considerable discretion should be used in attempting to compare absolute values obtained using different instruments.

It is necessary to point out too that the data obtained generally confirms what might have been reasoned on the basis of the construction of the various instruments used. The two spectrophotometers yielded sets of values which were closer to each other than they were to those obtained with the tristimulus colorimeters. While small errors in spectrophotometric data may result in errors in chromaticity values greater than differences apparent to the human observer *(3)*, and various sources of error in tristimulus measurements of chromaticity differences have also been reported *(2)*, is not a necessary conclusion that the method or instrument can be of no benefit to a food packer. For one thing, any of the instruments used possesses better "color memories" than the average human observers, i.e. they can be used to compare data obtained at a given time with data obtained some time before. Secondly, the demands of colorimetric control in the food industry are generally less rigorous than they are in other fields such as in paints or plastic, where production control within tolerance not exceeding the limits of perceptible difference is often required.

Acknowledgments

The authors are indebted to Professor Sargent Russell for his assistance in designing the statistical analysis of the data.

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Studies in Canning Processes

II. The Effects of the Variation with Temperature of the Thermal Properties of Foods

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(Manuscript received December 4, 1957)

As in part I of these studies *(4)*, this paper is concerned exclusively with solid food packs in which heating is by conduction. It does not apply to liquid or semiliquid packs in which movement of parts of the pack can take place during processing, and some heat transfer by convection occurs.

When considering changes of temperature in solid foods it is usually assumed that the thermal characteristics of the foods, such as the thermal conductivity and heat capacity, are constant when the temperature changes. This assumption is not only made when calculating rates of heating or cooling using known or assumed thermal properties but also underlies methods of evaluating these properties from experimental heating or cooling data.

It has long been known that the thermal properties of many substances vary to some extent with the temperature, but this variation is generally regarded as small enough to neglect.

The thermal properties of water, however, exhibit a greater variation than do those of most substances. Consequently the thermal properties of most foods would also vary significantly with the temperature as they contain large amounts of water. Values of the water content of solid packed canned foods vary between 70% and 90% except for fatty meats, such as ham or pork, which have values near 50%.

It is difficult to estimate, with any accuracy, effects due to expansion or contraction of the pack with changing temperature but they are expected to be quite small. During the heating phase, for example, the gradually increasing dimensions would mean a small increase in the distance through which heat has to travel, thus slowing down the rate of heat penetration, but at the same time there is a corresponding decrease in the heat capacity per unit volume having an opposite effect by tending to increase the rate of heat penetration.

THE THERMAL PROPERTIES OF WATER

Many measurements of the thermal properties of water at different temperatures were found in the literature. The various values for the density and specific heat agreed well but discrepancies were found between thermal conductivities reported by different workers.

The values for the conductivity used here were those of Riedel *(11)*. More recent determinations by Challoner and Powell *(2)* differ from these by about 1%, but this small difference would have little effect on the present work.

The values of the thermal properties of water used are summarized in Table 1. It will be seen that the thermal diffusivity increases by approximately 19% between 68° F. (20° C.) and 248° F. (120° C.), i.e. between an average room temperature and a typical retort temperature. The change is largely due to an increase of 14.5% in the thermal conductivity, but a decrease of about 4% in the value of the thermal capacity per unit volume (i.e. product of density and specific heat) also makes a significant contribution.

TABLE 1

The thermal properties of water at various temperatures

Temperature		Specific heat *(6)* cals/(g.) (° C.)	Density *(9)* g./(cm.)³	Conductivity *(10)* 10^{-3} cals/(cm.) (sec.) (° C.)	Diffusivity 10^{-3}cm.²/sec.
° F.	° C.				
32	0	1.0087	0.9999	1.350	1.338
68	20	0.9986	0.9982	1.431	1.436
104	40	0.9976	0.9922	1.500	1.515
140	60	0.9993	0.9832	1.558	1.586
176	80	1.0024	0.9718	1.598	1.640
212	100	1.0064	0.9584	1.624	1.684
248	120	1.0144	0.9434	(1.639)[1]	1.713

[1] Extrapolated.

Calculations with variable thermal properties. The equation of heat conduction cannot be solved analytically when the thermal properties are functions of the temperature. It is still possible, however, to calculate heating or cooling curves numerically. Such calculations are tedious even for mathematically simple shapes such as an infinite slab or an infinite cylinder but for a finite cylinder the labour required would be excessive. As the effects of the variation in thermal properties would be similar for a finite and an infinite cylinder calculations were made for the latter.

The thermal properties assumed in the calculations were those of immobilized water, given in Table 1; it was assumed that no convection heating could occur.

In the calculations the equation of heat conduction was first rewritten with changed variables as suggested by Eyres *et al.* (*5*, page 21). This equation was then integrated by the numerical procedure proposed by Crank and Nicolson *(3)*. A trial calcula-

tion was first carried out with constant thermal properties; this served as a check on the finite difference approximations used, the agreement being very good with the well-known analytical solution, Carslaw and Jaeger (*1*, page 174), and was also used as an estimate for part of the calculation with variable thermal properties.

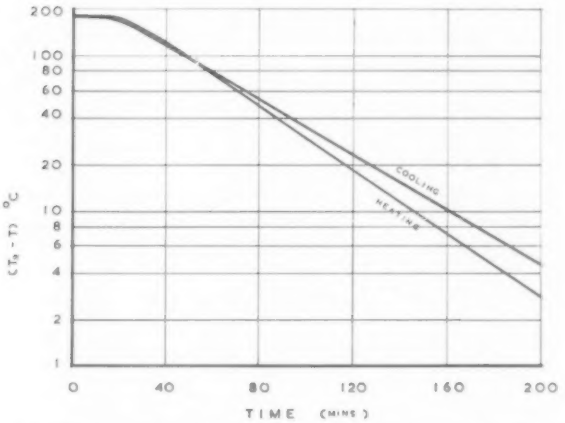

Figure 1. Calculated heating and cooling curves for an infinite cylinder of immobilized water, 5 cm. radius, heated and and cooled between 68° F. (20° C.) and 248° F. (120° C.).

The results of calculations for an infinite cylinder of radius 5 cm., heated and cooled between 68° F. (20° C.) and 248° F. (120° C.) are shown in Figure 1. The data are plotted in the usual way; time is plotted along one axis and along the other the logarithm of the difference in temperature between the centre of the cylinder and the heating or cooling medium. It can be seen that the shape of these curves is similar to most experimental or theoretical heating or cooling curves. In particular the later parts are linear within the accuracy of plotting, and f_h and j values can be estimated by the usual graphical methods. Values derived in this way are given in Table 2 together with values calculated for constant thermal diffusivities equal to those of water at 68° F. (20° C.) and 248° F. (120° C.).

TABLE 2

Heating and cooling of an infinite cylinder; values of the lag factor j and slope f_h at the centre of an infinite cylinder, radius 5 cm., with the thermal properties of immobilized water

Heating and cooling between 68° F. and 248° F.	j	f_h (min.)
Constant thermal diffusivity		
Heating and cooling phases: diffusivity coresponding to 68° F.	1.60	116
Heating and cooling phases: diffusivity corresponding to 248° F.	1.60	97
Variable thermal properties		
Heating phase	1.72	99
Cooling phase	1.43	116

Among the more important conclusions to be drawn from the calculations are:

1. The heating and cooling curves, taking into account the variation in thermal properties, have a similar form to curves obtained when those properties are constant.

2. There is a slight change in the lag factor j from the value 1.602 for constant thermal properties. The heating phase has a j value 7.5% higher and the cooling phase a value 10.6% lower.

3. The slopes of both curves have values near that for constant thermal properties using a diffusivity corresponding to the final temperature. Two factors could account for this: (a) for the last half of the heating or cooling period, the greater part of the cylinder is quite near the temperature of the heating or cooling medium; even the centre is less than 30° F. away, (b) the fact that the effective diffusivity is increasing during the heating phase (and decreasing during the cooling phase) would itself tend to make the f_h measured from an experimental curve approach that corresponding to a diffusivity appropriate to the final temperature.

APPLICATION TO FOODS

The above discussion applies to water. Foodstuffs, however, have thermal properties which differ from those of water because they contain between 10% and 30% of other substances. These properties will depend on the amount of the non-water constitutents and their thermal properties and to a small extent on other factors such as the natural cellular structure and, for some foods, on the pre-processing treatment.

Thermal diffusivities of most non-water constituents in foods are lower than for water and would not be expected to vary greatly with temperature. The diffusivities of foods will therefore be slightly less than the values given in Table 1 and discussed in earlier sections of the paper, and will be expected to undergo a smaller variation with temperature. From measurements made in this laboratory and from an examination of values reported in the literature, thermal diffusivities for foods are commonly from 5 to 20% less than for water.

With cans of food therefore the effects of the variation in thermal properties on heating and cooling curves would take the same form as has been found for water but would be slightly smaller in magnitude.

Experimental demonstration of the effects. Evidence from a number of sources has confirmed that the variation of thermal properties with temperature does, in practice, affect heating and cooling curves in the way shown.

Some evidence was given in Part I of this series (*4*). For 5 cans the mean diffusivity of a bean and bentonite mixture heated in a well-stirred water bath at 104° F. (40° C.) was 1.34 x 10^{-3}cm.^{2}/sec. The mean for 6 cans of the same batch of the product (cans A, B, E, F, H and I of Table 1, Part I) in a retort at 240° F. (115.6° C.) was 1.72 x 10^{-3}cm.^{2}/sec. Compared with this change of 28%, other cans exhibited changes between 15 and 20% for the same

temperature range. Although no measurements of the water content were made at the time, measurements made recently on a similar product gave a water content of 75%. The change of diffusivity for pure water between the same temperatures, from Table 1 above, is 13% from 1.51 x 10^{-3} to 1.71 x 10^{-3} cm.^{2}/sec.

It should be noted that when calculating canning processes in this laboratory the dimensions of the products are used. These are obtained from the can dimensions by subtracting 1/8 in. from the overall can diameter (thus allowing for the can seam) and subtracting 1/4 in. (can seam) and the depth of the headspace from the overall length. The depth of the headspace depends on the can in question; it may be 1 cm., 10% of the can length, or some other appropriate value. Thus for a No. 1 tall can (301 x 411) with a headspace of 1 cm., for any calculation the values used for the diameter and length are 7.46 cm. and 10.30 cm., respectively. This procedure clearly amounts to neglecting any lag in heating due to the thermal capacity of the can.

More recent experimental results on the bean-bentonite product are given in Table 3. If the diffusivities quoted are regarded as corresponding to the final temperature for both the heating and cooling phases, the increases in diffusivity from 86° F. (30° C.) to 214° F. (101° C.) for the 4 cans are respectively 11, 16, 19 and 10%. These compare with an increase of 14% for the diffusivity of water. The heating and cooling curves obtained with can 2 are given in Figure 2. They are clearly similar in form to the theoretical curves in Figure 1.

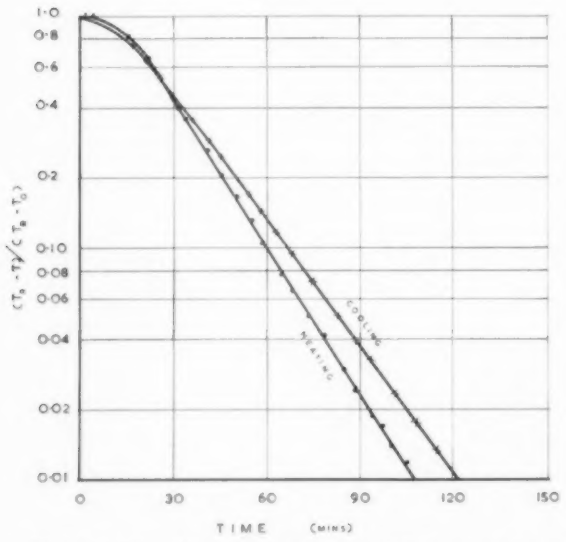

Figure 2. Experimental heating and cooling curves for a 301 x 411 can of bean-bentonite mixture.

Experiments were also carried out with small circular cylinders (diameter 2 in., length 2 in.), some made of various plastics, others of agar gel. A number of temperatures between 32° F. (0° C.) and 122° F. (50° C.) were used.

Typical figures taken from heating and cooling curves of agar gel are given in Table 4. The value of the diffusivity at 43.7° F. (6.5° C.) was 1.35 x 10^{-3} cm.^{2}/sec. and at 129.2° F. (54° C.), 1.53 x 10^{-3}cm.^{2}/sec. Allowing for the 5% or so of agar in the gel, these compare well with the values 1.37 x 10^{-3}cm.^{2}/sec. and 1.56 x 10^{-3}cm.^{2}/sec. for water.

TABLE 4

Heating and cooling of cylinder of agar gel. Gel made up of 95% water, 5% agar by weight. Cylinder radius 2.54 cm., length 5.08 cm.

Repeated runs of heating and cooling on same cylinder

	Initial temp. °F.	Final temp. °F.	Lag factor j	Slope f_h (min.)	Diffusivity (10^{-3}cm.^{2}/sec.)
Heating	43.8	129.2	2.09	19.1	1.57
Heating	43.4	129.3	1.91	20.1	1.49
Cooling	129.2	43.8	1.67	22.5	1.33
Cooling	129.3	43.6	1.75	21.9	1.37

The interpretation of the results was further confirmed by an experiment with a mixture of 50% water, 50% ethylene glycol, by volume, made into a gel with 5% agar. From the literature it was found that ethylene glycol has a negative temperature co-efficient, that of water being positive. The diffusivities and their variation with temperature were such that, if the two liquids are mixed in the correct proportions, the mixture should have a fairly constant diffusivity.

This was confirmed experimentally by measuring the temperature with a fine wire nichrome-constantan thermocouple (40 S.W.G.) at the centre of a cylindrical block 2 in. diameter, 2 in. long when heated and cooled in water baths at 130° F. (55° C.) and 41° F. (5° C.) respectively. Heating and cooling curves were found to be identical within the accuracy of the experiment with a lag factor of 2.02 and a slope f_h of 27.0 mins. The latter corresponds to a diffusivity of 1.11 x 10^{-3}cm.^{2}/sec.

TABLE 3

Heating and cooling of bean-bentonite mixture. Centre of No. 1 tall (301 x 411); product containing 75% water. Heating in boiling water,[1] cooling in well-stirred water bath

Can	Temperature range (°F.)	Lag factor j	Slope f_h (min.)	Thermal diffusivity (10^{-3}cm.^{2}/sec.)	Temperature range (°F.)	Lag factor j	Slope f_{ct} (min.)	Thermal diffusivity (10^{-3}cm.^{2}/sec.)
1	76.3–213.6	1.95	48.5	1.55	213.1–86.5	1.70	54.0	1.40
2	76.3–213.6	1.92	47.0	1.60	213.1–86.5	1.66	54.5	1.38
3	76.3–213.6	1.98	44.5	1.69	213.1–86.5	1.55	53.0	1.42
4	76.3–214.2	1.84	51.0	1.49	214.8–86.7	1.52	55.5	1.36

[1] The high boiling points quoted occurred in a large vessel with a small orifice to the atmosphere which was itself at a pressure of 772 mm. Hg (corresponding to B.P. = 212.8° F.).

Hurwicz and Tischer *(7, 8)* in their series of papers on the heat processing of beef reported experimental values of the thermal diffusivity of the pack which depended on the temperature of the retort, the higher the retort temperature the larger the diffusivity.

Some results were quoted on No. 2 cans *(7)* but the most extensive studies were carried out on 300 x 308 cans *(8)*. Mean values quoted for the slopes of heating curves (when estimated by fitting regression lines) for retort temperatures between 225° F. (107.2° C.) and 315° F. (157.2° C.) ranged from 33.51 minutes to 41.98 minutes with an average value of 36.63 minutes. The latter value, for a 300 x 308 can, corresponds to a diffusivity of 1.71 x 10^{-3}cm.^{2}/sec. They showed that the variations in slope with retort temperature were statistically significant. They found that the slopes of the cooling curves corresponded to lower values of the diffusivity than the heating curves but they did not vary significantly with retort temperature. This would be expected if, as was indicated above, the slope of the cooling curve should depend on the temperature of the cooling water which was presumably fairly constant.

The lag factor. The value of the lag factor at the centre of a can is theoretically 2.04. This value holds only under certain conditions; in particular the thermal properties of the pack must be constant, the initial temperature must be uniform, and the temperature of all surfaces changed suddenly from the initial value to that of the heating or cooling medium.

For several reasons experimental j values are generally different from this, as may be seen from the examples quoted in Table 3.

The processing conditions may differ appreciably from those assumed theoretically. The come-up time of a retort is known to affect j significantly, the longer the come-up and the smaller the can, the greater the effect. The temperature in the can at the beginning of a heating or cooling process may not be uniform. This may occur if, before processing, the pack is filled hot and allowed to cool for some time or is preheated in an exhaust box.

Even when departures from the ideal processing conditions are negligible, however, there are other factors which tend to give j values different from 2.04.

As has been seen the variation of thermal properties with temperature tends to increase slightly the j value for the heating phase and decrease it for the cooling phase.

The thermal resistance of the headspace also affects j. Calculations have shown that for a rate of heat transfer through the headspace of 7.6 BTU/(ft.)^2 (hr.)(° F.) the asymptote of the heating curve of a No. 2½ can (401 x 411) would have a j value at the centre of 1.95, about 4% below 2.04. For the squat No. 1 Tuna can (401 x 206) the value is 1.88, 8% below 2.04.

The factors discussed so far affect the j value of the asymptote, but as has been pointed out by Olson and Jackson *(10)*, experimental j values are further affected by the slow approach of the actual curve to the asymptote. For a very tall can, for example, the rate of heating through the sides is so rapid that heating through the ends may be close to the asymptote only late in the process. This would tend to diminish the j value estimated visually from the experimental curve particularly if points near the end of the process, where experimental accuracy is rather low, are ignored. A similar effect occurs with very squat cans, cans where the ratio of diameter to length is near unity being least affected.

Values of j at can centres obtained by fitting lines visually to calculated data in the usual manner, for two can sizes neglecting and including the thermal resistance of the headspace are given in Table 5.

TABLE 5

Values of the lag factor j for the theoretical asymptote and for the line fitted visually to calculated data

Can size	Lag factor j			
	Neglecting headspace		Including headspace	
	Theoretical asymptote	Actual curve	Theoretical asymptote	Actual curve
No. 2½ (401 x 411)	2.04	2.00	1.95	1.88
No. 1 tall (301 x 411)	2.04	1.95	1.95	1.83

Curves for No. 1 tall can. The factors discussed above are best illustrated by considering the heating and cooling phases for a particular can. A No. 1 tall can (301 x 411) is a size frequently used with solid packs. This can will be considered filled with a product whose thermal diffusivity is at all temperatures 10% less than that of water.

Labelling the factors being considered as follows:

(a) the variation with temperature of the thermal properties of the pack,
(b) the resistance to heat flow of the headspace,
(c) the slow approach to the asymptote of the curves due to different rates of heating through the sides and ends of the cans respectively.

If the effects produced by these are additive it is then possible to estimate the values of the slopes and lag factors for the heating and cooling curves giving values which are believed to be correct to within about 5%.

Heating curve. Due to factor (a) the appropriate value of the diffusivity to be used in estimating the slope f_h is that at the retort temperature 248° F. (120° C.). This gives a value of 48.9 min. if factor (b) is neglected. When (b) is taken into account this value is increased to 50.7 min. This is further increased to 51.6 min. for the actual heating curve due to factor (c).

The lag factor j would have the well-known value 2.04 at the centre of a pack with constant thermal properties under simple processing conditions. However, factor (a) increases this by 7%, factor (b) diminishes it by 4.5% and factor (c) by 10%. The value is then about 7.5% below 2.04; namely, 1.90.

Cooling curve. Due to factor (a) the value of the slope f_c, is calculated from the thermal diffusivity of the pack at the temperature of cooling water, namely 68° F. (20° C.), is 58.3 min. Factor (b) increases

this to 60.5 min. and factor (c) increases it further to 61.5 min. In estimating the effect of factor (b) it was assumed that the rate of heat transfer through the headspace during the cooling phase was the same as during the heating phase, namely 7.6 BTU/(ft.)^2 (hr.)(° F.). This although probably correct for the beginning of cooling is too high for the later parts. Towards the end of cooling, when the top surface of the pack is below 100° F. (37.8° C.) this rate would be nearer 2 BTU/(ft.)^2(hr.)(° F.). Using a lower rate would further increase the value of f_cl.

From the value 2.04 the j value is decreased by 10% by factor (a), decreased by 4.5% by factor (b) and by a further 10% by factor (c). This gives a value about 25% below 2.04; namely 1.53. There will be a further small decrease in j due to the fact that, for any actual process, the centre temperature is below retort temperature at the beginning of cooling.

It is important to realise that, although the linear part of the cooling curve, with its characteristic slope and lab factor, has been used freely in the present paper to discuss the processes involved, this part of the curve is not useful in estimating the lethal value of a canning process. The cooling curve does not become approximately linear until the temperatures are well below the lethal region and the part which is of practical importance is the initial non-linear part.

Acknowledgments

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Lindane Residue Changes During the Fermentation and Processing of Pickles[a,b,c]

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THE RELATIONSHIP of insecticide residues to food products is of increasing importance as the amount of literature on the subject attests. Despite this fact, the literature is by no means oversupplied with reports on quantitative amounts of insecticide residues on processed foods. To a much greater extent, amounts of residues on raw produce (fruits and vegetables) have been reported. It is of great importance to know the amounts of insecticide residues on and in our food, a point emphasized by McKay *(4)*, who has related the current data on the toxicity of new insecticides to the consuming public. The study reported here was made to determine quantitatitvely the amount of lindane (gamma-hexachlorocyclohexane) on cucumbers from various insect control schedules with lindane, and to investigate the effect of fermentation and processing on this residue. Of interest in connection with this study was the work reported by Hornstein *(2)*, who found no evidence to indicate that benzene hexachloride accumulates in the soil with repeated application of the insecticide. Peanuts that were grown on plots treated the previous year with the insecticide did not accumulate the compound. Also of interest was the report of Reynolds *(5)* that 1.8 p.p.m. of benzene hexachloride was found in peanut butter made from peanuts grown in soil treated with the insecticide.

MATERIALS AND METHODS

The growing, preparation and brining procedures which were used in this study have been reported *(3)*. For the 1952 and 1953 experiments, harvested cucumbers, varieties Earliest of All and Chicago Pickling respectively, were sprayed with a solution of lindane at the rate of one pound of 25 per cent wettable lindane per 100 gallons of water, and the controls were treated with tap water. Cucumbers, variety Model, from replicated insect-disease control field plots were used in 1954. Four treatment schedules and a control were employed: namely Block I: 1% lindane dust and a 7.5% captan dust; Block II: lindane spray (1 lb. 25% wettable per 100 gal.); Block III: combination spray of lindane (1 lb. 25% wettable per 100 gal.) plus captan (2 lb. 50% wettable per 100 gal.); Block IV: combination spray of lindane (1 lb. 25% wettable per 100 gal.) plus methoxychlor (2 lb. 90% wettable per 100 gal.); and Block V: controls (not treated). Plots were treated 7 times prior to harvesting the experimental samples, with the last application the previous day.

Cucumber samples, variety Ohio MR-17, for lindane residue analysis were taken from replicated insect-disease control field plots in 1955. Four treatment schedules and a control were employed; namely, Block I: lindane spray (1 lb. 25% wettable per 100 gal.); Block II: lindane spray (2 lb. 25% wettable per 100 gal.); Block III: combination spray of lindane (1 lb. 25% wettable per 100 gal.) and zineb (2 lb. per 100 gal.); Block IV: combination spray of lindane (1 lb. 25% wettable per 100 gal.) and captan (2 lb. 50% wettable per 100 gal.); and Block V: control (not treated). Eleven spray applications were made prior to harvest with the last one being made the previous day.

Desalting of the cured salt stock was by a modified cold water method in the laboratory. Cold tap water was used for the first two leachings with compressed air for circulation during periods of 17 and 8 hours. The third water was heated to 150° F. on the stock and permitted to cool during a 17-hour period without circulation. At the end of the leaching period, the water temperature was 90° F. After draining the third water from the stock, a strong spray of water was used to rinse the surface of the stock.

Spray treatments were replicated 3 times in 21 gallon vats, and each vat of desalted stock was manually size graded into large, medium and small lots. The large size grade was made into sour pickles; the medium size into dills, and the small size into sweets.

Sour Pickles. The large size stock was packed directly into one-gallon jars. A 60-grain vinegar containing a mixed spice oil formula[d] was used as a cover liquor. Samples were stored one month for equalization of the sour liquor with the stock.

Dill Pickles. Medium size stock was packed directly into one-gallon jars. A cover liquor composed of 30-grain vinegar, 20° Salometer and 5 ml. of dill oil emulsion[d] per gallon of solution was used. Samples were stored for one month to permit equalization.

Sweet Pickles. Sweetening of the small stock was done in 4-gallon stone jars. Initially, a liquor of 60-grain vinegar and 15° Brix was used to cover the stock. After 24 hours the liquor concentration was increased to 20° Brix, and at the end of each succeeding 24-hour period the liquor concentration was increased to 20, 30, 35, 40 and 45° Brix, respectively. For the next two 24-hour periods the liquor was adjusted back to 45° Brix. A fresh sweet liquor whose composition was 43° Brix, 19-grain vinegar and 12 ml. of formulated spice oil emulsion[d] per gallon of liquor was placed on the sweetened stock in one-gallon jars. An equalization period of one month was given the samples prior to analysis.

Samples for lindane (gamma-hexachloro-cyclohexane) analyses were taken after each of the 3 major steps in the processing of cucumbers into pickles. The fresh cucumbers were sampled after the spray treatments and again when the curing process was completed. The final sampling was from the finished sour, sweet and dill pickles. A 5 to 6 pound aliquot was drawn from each treatment replication at each sampling which was a cross-section of each replication.

Preparation of samples for analysis was the same throughout the 4 years of the work. The samples in a liquid medium (salt stock, sour, sweet and dill pickles) were drained on an 8-mesh screen for 2 minutes. They were cut into one-fourth inch cubes and placed in a Waring blender for a blending time of 5 minutes. This period of time was found to reduce the samples to a uniformly fine puree. Each blender load of an aliquot was transferred to a stainless steel bucket and the

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[b] Based on a dissertation in partial fulfillment of the Doctor of Philosophy.

[c] Presented before the Seventeenth Annual Meeting of the Institute of Food Technologists, Pittsburgh, Pa., May 13, 1957.

[d] Griffith Laboratories, Inc.

blended material thoroughly mixed. About 2 pounds of the blended material was placed in a plastic container and sealed. All the raw cucumber samples were stored at 0° F. and the self preserved salt stock, sour, sweet and dill pickles were stored at 40° F. prior to being analyzed.

The Agricultural Chemistry Laboratory, Missouri Agricultural Experiment Station, did the analysis of the samples for benzene hexachloride. The Schechter-Hornstein method *(8)* for benzene hexachloride was used. Gehrke and Bevert *(1)* have reported on a study of the critical points in the Schechter-Hornstein colorimetric method for benzene hexachloride. A total of 136 different samples was analyzed by the Station Laboratory during the 4-year period.

RESULTS

Results of the analysis of the samples from the 1952 season are shown in Table 1. The raw sprayed cucumbers were found to contain 10.4 p.p.m. and the salt stock contained 10.0 p.p.m. of gamma benzene hexachloride. In the finished pickles, the insecticide was found in the sour, sweet and dill style pickles at a concentration of 12.0, 2.75 and 4.0, respectively. This residue resulted from a spray solution of 1 pound of 25% wettable lindane per 100 gallons of water. The spraying technique was such that it should be expected to leave a maximum residue of the spray material.

Results of the analysis of samples from 1953 are shown in Table 2. The raw sprayed cucumbers were found to contain

TABLE 1

Amount of lindane residue on fresh weight basis from 1952 samples

	Raw cucumbers	Salt stock[2]	Pickle types		
			Sour	Sweet	Dill
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Lindane Spray[1]	10.40	10.00	12.00	2.75	4.00
Control	3.08	0.21	0.40	2.15	0.72

[1] One pound of 25% wettable lindane per 100 gallons of water.
[2] Covered with 40° Salometer brine which was maintained during fermentation.

TABLE 2

Amount of lindane residue on fresh weight basis from 1953 samples

	Raw cucumbers	Salt stock	Pickle types		
			Sour	Sweet	Dill
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Lindane Spray[1]	11.72	0.05	0.85	1.12	0.88
Control	1.70	0.75	1.19	0.45	0.24
Lindane Spray[1]	11.72	0.50[2]	0.49	0.31	0.48
Control	1.70	1.65[2]	0.20	0.65	0.37

[1] One pound of 25% wettable lindane per 100 gallons of water.
[2] Covered with 46° Salometer brine which was permitted to equalize.

11.72 p.p.m. of gamma benzene hexachloride. This is approximately the same amount that was present on the 1952 raw cucumbers. The lindane-sprayed salt stock samples contained less than 1 p.p.m., and the sour, sweet and dill had 1 p.p.m. or less of the spray material. These data are considerably lower than similar samples from the 1952 work; yet they were sprayed in the same manner.

Residue of lindane on the samples from the controlled spray schedules of 1954 was very low (see Table 3). The raw cucumbers from the spray plots contained about 1 p.p.m. of lindane. The salt stock and processed sour, sweet and dill pickles contained from 0.54 p.p.m. to no detectable residue of lindane.

Analysis for lindane on samples from two fermentations in which known amounts of lindane and i-inositol were added is of interest (see Table 3). Enough lindane (1.13 g.) was added to each fermentation to make a 10 p.p.m. concentration in the cucumbers (125 pounds) and brine (15 gallons). In addition

TABLE 3

Concentration of lindane residue on fresh weight basis from 1954 samples

Control schedules	Raw cucumber	Salt stock	Pickle types		
			Sour	Sweet	Dill
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Lindane and Captan dust	0.93	0.54	0.41	0.42	0.20
Lindane Spray	0.73	0.00	0.00	0.05	0.08
Lindane and Captan spray	0.85	0.00	0.00	0.42	0.07
Lindane and Methoxychlor sspray	1.07	0.06	0.00	0.00	0.00
Control	1.00	0.12	0.00	0.00	0.06
No. 11 Lindane and Inositol	....[1]	4.25	3.73	4.40	5.50
No. 12 Lindane	....[2]	7.30	4.68	8.10	7.00

[1] 1.13 g. of lindane and 1.13 g. i-inositol placed in brine and cucumbers (30-gallon volume). Equivalent to 10 p.p.m. of each material.
[2] 1.13 g. of lindane placed in brine and cucumbers (30-gallon volume). Equivalent to 10 p.p.m. of material.

sample number 11 was treated with 1.13 g. of i-inositol which would yield a 10 p.p.m. solution. The number 11 sample salt stock after curing had 4.25 p.p.m. of lindane; and sample number 12 salt stock had 7.30 p.p.m. of lindane. The sour, sweet and dill pickles from sample number 11 contained 3.73, 4.40 and 5.50 p.p.m. of lindane, respectively; whereas, similar pickles from sample number 12 had a greater amount of lindane present. Sour, sweet and dill pickles from the latter sample contained 4.68, 8.10 and 7.00 p.p.m. of lindane, respectively.

As shown in Table 4 the concentrations of lindane on the samples from the 1955 field control schedules were very low. Data from these plots agree very well with the 1954 results.

TABLE 4

Concentration[1] of lindane residue on fresh weight basis from 1955 samples

Control schedules	Raw cucumbers	Salt stock	Pickle types		
			Sour	Sweet	Dill
	p.p.m.	*p.p.m.*	*p.p.m.*	*p.p.m.*	*p.p.m.*
Lindane (1 lb.)	0.35	0.14	0.13	0.18	0.34
Lindane (2 lb.)	0.10	0.23	0.16	0.15	0.26
Lindane & Zineb	0.15	0.25	0.21	0.18	0.17
Lindane & Captan	0.25	0.28	0.14	0.27	0.18
Control	0.00	0.23	0.06	0.14	0.17

[1] Each value is the average of three independent determinations.

DISCUSSION

Cucumbers which have been treated directly with a spray containing one pound of 25% wettable lindane per 100 gallons of water can be expected to contain about 11 p.p.m. of benzene hexachloride residue. The raw cucumbers contained 10.4 p.p.m. in 1952 and 11.72 p.p.m. in 1953, and in both cases they were treated with a spray of the same concentration. In actual practice, it should be very difficult to approach these amounts of lindane residue. Undoubtedly the protection afforded the cucumber fruit by the foliage of the plant would prevent the accumulation of large amounts of insecticide residue. Results of the analysis of the raw cucumbers from the field plots in 1954 and 1955 indicate that this is the situation. A concentration of 1.07 p.p.m. of lindane was the highest residue found from the field trials. In nearly all cases the amount of residue on the raw cucumber was greatly reduced by the subsequent processing.

Salt stock in 1952 was found to contain 10.0 p.p.m. of benzene hexachloride; whereas, the 1953 salt stock contained 0.05 p.p.m. of benzene hexachloride. The amount of residue found in 1952 would appear to be too high when it is understood that the cucumbers remained in an approximately equal volume of brine for 7 months. It would seem that the dilution by the brine would reduce the 1952 salt stock residue to 5 or 6 p.p.m.

An explanation for the greater reduction in lindane residue during the fermentation and curing of the 1953 cucumbers than in the 1952 season might be the extent of vat closure and the brining schedules that were used each of the two years. In 1952 the heads were returned to the 21-gallon kegs after filling with cucumbers, and the side hole (3 in. diameter) was the extent of brine exposure to the atmosphere. In 1953 the heads were not returned to the kegs; and with greater brine surface exposed there was more film yeast growth than in 1952. The brine densities were lower in 1953 than in 1952 (kept at 40° Sal.) which permitted a greater total growth of microorganisms. In the 1954 salt stock, the residue ranged from 0.50 to 0.0 p.p.m. and these data are similar to the 1955 results.

Sour, sweet and dill pickles from the 1952 work were found to contain considerably more spray residue than the 1953 pickles. The value for sour pickles in 1952 is somewhat higher than the concentration of residue found on the raw cucumber. No logical explanation is possible, for the vigorous leaching of the salt stock would tend to remove the residue rather than increase it. In 1952 the hot water desalting method was used, whereas in 1953 a modified cold water desalting method was used. Due to the low amount of residue on the 1953 salt-stock, it is not possible to compare the efficiency of the two desalting methods. The amount of residue found on the 3 styles of pickles in 1954 and 1955 was extremely low. In all cases less than 0.5 p.p.m. was present in each of the 3 styles of pickles. The desalting method used in 1954 and 1955 was the same as 1953.

Reduction in the amount of residue due to processing was of interest in the case of numbers 11 and 12. In number 11 the concentration of residue was 4.25 p.p.m. and in number 12 it was 7.3 p.p.m. Both fermentations were treated with 10 p.p.m. Lindane and number 11 was treated with an additional 10 p.p.m. of i-inositol. After the salt stock from the two fermentations was processed into pickles, there was little or no reduction in the amount of residue. The difference in the amount of residue in the salt stock of the two treatments was maintained in the finished pickles. Again, the sweet and dill pickles from both fermentations were found to contain a higher amount of residue than the salt stock. In only 3 cases it was found that the observed data were higher than the theoretical solubility of benzene hexachloride in water. As reported by Slade *(7)* the maximum solubility of gamma-benzene hexachloride in water is 10 p.p.m.

It would appear from the data reported that the residue from lindane spray on cucumbers in the field and after fermentation and processing into pickles is insignificant; however, a concentration of 10 p.p.m. could result if harvested cucumbers are sprayed directly.

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Factors Influencing Consumer Opinion of Canned Bartlett Pears

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CONSUMER ACCEPTANCE of canned fruit is influenced more by flavor than by any other quality characteristic. Flavor quality, in turn, is strongly affected by the sugar concentration of the fruit. In a series of investigations conducted in this laboratory, trained taste panels associated flavor with sweetness in samples of aqueous solutions *(8)* and fruit nectars *(9)*. A greater flavor intensity was ascribed to sweeter samples up to an optimum sugar level, beyond which the excess sweetness interfered with flavor perception. Further work established that consumer acceptance as well as laboratory panel flavor evaluation depended upon an optimum acidity level as well as an optimum sugar concentration *(5, 6, 9)*.

Optimum sweetness levels, as determined by consumer surveys, have been reported for canned cling peaches *(5, 6)* and for canned apricots *(10)*. In the latter paper, the literature on consumer acceptance techniques, with emphasis on household-level surveys, is reviewed.

The present paper discusses a household consumer panel's opinion of Bartlett pears of varying acidity, canned at five sugar levels. The objectives of the survey were: (a) to establish optimum sugar to acid relationships for canned pears; (b) to determine what factors influence consumer likes and dislikes for the fruit; and (c) to study consumer buying behavior relative to commercially-canned pears.

METHODS AND MATERIALS

Raw material. The Bartlett pears evaluated in this investigation were grown in Santa Clara and in Lake Counties. Fruit from the latter growing area was characterized by a higher total acidity. The pears were harvested at a uniform maturity, ripened, then sorted by color under a standard light source. Processing was conducted in the pilot plant of the Department of Food Technology as follows: after peeling and trimming, the pear halves were packed into 401 x 411 (No. 2½) size cans. A fill of 19 oz. of fruit and 11 oz. of sucrose syrup of 30°, 40°, 50°, 60°, or 70° Brix was used. After vacuum closing, the canned fruit was cooked in an Andersen-Barngrover atmospheric, rotary cooker at 210° F. for 32.5 min.

A storage period of 6 months assured complete equilibration between fruit and sugar syrup, after which time, chemical analyses of randomly selected samples were made (Table 1) and consumer preferences were obtained.

Consumer sampling. Shasta County, in northern California, was selected as the test location. The county is in the center of a large lumber industry and has a population of 52,000. Most of the households in the sampling were situated in Redding, the county seat (pop. 14,000). A total of 400 families, selected at random from the telephone directory agreed to participate. Although no attempt was made to select families in particular income groups or by occupation, the following classification by occupation of the head of each household agrees fairly well with the Redding Chamber of Commerce's estimate of the area:

White collar	27%
Skilled craftsmen	18%
Laborers and farmers	17%
Professionals	16%
Lumberers	12%
Retired	8%
Other	2%

Table 2 classifies the survey participants by age and sex.

TABLE 1

Chemical analyses of canned Bartlett pears

In-going Brix	Cut-out Brix	pH	Total acid[2]	SS/A[3]
Santa Clara County[1]				
			%	
30°	18.5°	3.9	0.134	138.2
40°	22.6°	3.9	0.131	171.9
50°	26.3°	3.9	0.140	188.2
60°	29.9°	3.9	0.146	209.2
70°	32.7°	3.8	0.139	236.8
Lake County[1]				
30°	18.9°	3.8	0.168	112.6
40°	22.8°	3.7	0.154	148.2
50°	26.6°	3.6	0.166	159.6
60°	30.6°	3.8	0.160	191.4
70°	33.7°	3.8	0.154	218.5

[1] Average of 3 analyses.
[2] As per cent citric acid.
[3] Soluble solids to acid ratio.

TABLE 2

Classification of participants by age and sex

Age group	Group A[1]		Group B[2]		Composite		Totals
	Males	Females	Males	Females	Males	Females	
6–16	74	65	90	82	164	147	311
16–25	29	31	29	21	58	52	110
25–50	129	143	140	146	269	289	558
Over 50	52	57	50	44	102	101	203
Totals	284	296	309	293	593	589	1182

[1] Families evaluating pears grown in Lake County.
[2] Families evaluating pears grown in Santa Clara County.

Experimental design. During January 1957, 5 cans of pears, one can from each of the 5 sweetness levels, were delivered to each household. Numbers from 1 to 400 had been assigned at random to the families so that pears grown in Lake County were distributed to even-numbered homes and Santa Clara pears were delivered to households assigned odd-numbers. Unlabelled cans, distinguishable only by a randomly selected, two-digit number, were delivered to each home. The consumers were informed that the pears had been "canned in different ways" and therefore had no knowledge of the sugar and acidity variables. An instruction sheet of directions specified that the cans were to be opened singly, in any order the homemaker wished. However, the fruit was to be served cold, as a part of a regular family meal, allowing at least one major meal between tastings.

Individual family members indicated their opinion of the fruit on a score card of 7 descriptive terms: *like extremely, like*

very much, like slightly, don't like but will eat, dislike moderately, dislike very much and dislike extremely. To determine the basis for the reactions, two questions were asked: "What did you like about this can of pears?" and "What did you dislike about this can of pears?" Information was collected regarding age and sex of the taster, the date the fruit was tasted, and the meal at which tasted. In addition to the individual score sheets, the homemaker completed a questionnaire asking for the following:

1. Height, weight, amount of daily physical activity, and occupation of adults over 25 years of age.

2. Frequency of consumption of commercially canned and home canned pears.

3. The brand of commercially canned pears ussually purchased and reason for buying that brand.

The entire month of February was allowed for evaluating the fruit; completed questionnaires were returned by mail.

Second study. In order to determine the effect of the season of the year (winter vs. summer) on consumer responses, 100 families were selected at random from the original group and were asked to repeat the same tasting procedure with the same pear pack, in August 1957.

RESULTS AND DISCUSSION

A response of 94.5% of the original 400 families was received, representing approximately 5,000 individual evaluations. To facilitate statistical analyses, numbers ranging from 1 to 7 were assigned to the 7 descriptive terms on the score cards, with the higher number denoting a greater degree of liking. Analysis of variance was performed on the average scores within each category being tested *(4, 6)*. The average scores from 194 families who judged pears grown in Santa Clara County and from 184 families who scored pears from Lake County are plotted in Figure 1. The two lower sweetness levels of the Santa Clara fruit (18.5° and 22.6° cut-out Brix) were liked equally well and were scored higher than fruit containing greater amounts of sugar. The second level, 22.8° Brix, was considered the best sample of the Lake County fruit.

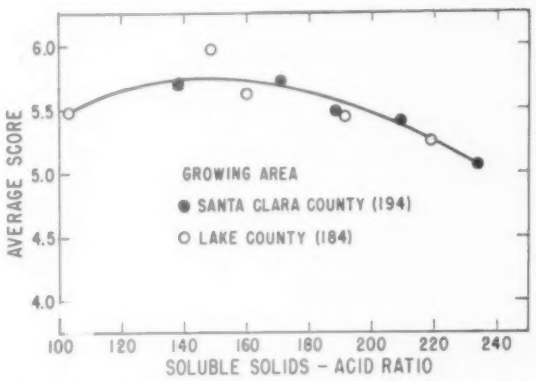

Figure 1. Redding survey, Bartlett pears, February 1957.

Pears receiving the highest scores had a soluble solids to acid ratio of between 138 and 171.

Evaluation of the fruit by a 15-member laboratory taste panel showed a definite preference for sugar levels of 22.8° and 18.5° Brix for Lake County and Santa Clara County pears, respectively.

Effect of age and sex. No significant differences in scoring were observed between the males and females participating in the survey (Table 3), although slightly higher scores were assigned by females to Santa Clara pears and by males to Lake pears. There was a very highly significant effect of age group on average scores with a tendency for the youngest and oldest age groups to prefer the sweeter pears as well as to assign higher values to all the samples. This effect is more apparent in the group who tasted Santa Clara fruit wherein each age group responded differently to the treatments as indicated by the highly significant interaction between age and treatment. Previous consumer tests had shown that men liked

TABLE 3

Effect of sex and age on average scores for canned Bartlett pears

Cut-out Brix	Santa Clara County—194 families					Lake County—184 families				
	18.5°	22.6°	26.3°	29.9°	32.7°	18.9°	22.8°	26.6°	30.6°	33.7°
No. evaluations	590	579	581	594	580	555	547	564	566	549
Total average score	5.68	5.69	5.55	5.36	5.23	5.45	5.94	5.55	5.32	5.23
Reaction by sex										
Males	5.67	5.67	5.52	5.42	5.22	5.48	5.89	5.57	5.39	5.28
Females	5.70	5.71	5.57	5.30	5.24	5.42	5.99	5.54	5.25	5.19
Reaction by age										
Under 16	5.83	5.86	5.67	5.62	5.47	5.51	5.88	5.65	5.44	5.53
16–25	5.61	5.29	5.18	5.21	4.66	5.45	6.00	5.11	5.16	4.90
25–50	5.62	5.61	5.48	5.18	5.13	5.34	6.01	5.59	5.23	5.08
Over 50	5.63	5.78	5.70	5.54	5.38	5.68	5.80	5.56	4.52	5.41

Analysis of variance

Source	Santa Clara County					Lake County				
	Sums of squares	Degrees of freedom	Mean square	F ratio	L.S.D.[1]	Sums of squares	Degrees of freedom	Mean square	F ratio	L.S.D.[1]
Total	3.7764	39				4.0213	39			
Treatments	1.4274	4	0.3568	12.56***	0.390	2.2892	4	0.5723	40.02***	0.274
Sex	0.0194	1	0.0194			0.0672	1	0.0672	4.70	
Age	1.4389	3	0.4796	16.89***	0.302	0.4918	3	0.1639	11.46***	0.219
Sex x treatment	0.0609	4	0.0152			0.1379	4	0.0345	2.41	
Sex x age	0.0787	3	0.0262			0.1605	3	0.0535	3.74*	
Age x treatment	0.4103	12	0.3419	12.04***		0.7033	12	0.0586	4.10*	
Error	0.3408	12	0.0284			0.1714	12	0.0143		

[1] Least significant difference between means at the 1% level of probability.
*Significant at P = 0.05. ***Significant at P = 0.001.

TABLE 4

Effect of frequency of consumption on average scores for canned Bartlett pears

Frequency	Santa Clara County						Lake County					
	Average no. families	Cut-out Brix					Average no. families	Cut-out Brix				
		18.5°	22.6°	26.3°	29.9°	32.7°		18.9°	22.8°	26.6°	30.6°	33.7°
Several times per week	30	5.47	5.67	5.77	5.03	5.52	39	5.51	5.78	5.05	5.05	5.30
Several times per month	168	5.61	5.77	5.74	5.39	5.28	137	5.42	5.89	5.50	5.29	5.34
Several times per year	142	5.72	5.54	5.45	5.13	5.06	150	5.50	6.05	5.59	5.34	5.17
Never	24	5.48	5.25	5.00	5.00	4.88	27	5.08	6.30	5.37	5.22	4.81

Analysis of variance

Source	Santa Clara County				Lake County			
	Sums of squares	Degrees of freedom	Mean square	F ratio	Sums of squares	Degrees of freedom	Mean square	F ratio
Total	3.6736	39			5.1335	39		
Treatment	1.3975	4	0.3494	23.77***	3.6428	4	0.9107	76.53***
Frequency	1.1643	3	0.3881	26.40***	0.1894	3	0.0631	5.30*
Sex	0.0449	1	0.0449	3.05	0.0002	1	0.0002	
Sex x treatment	0.0488	4	0.0122		0.0402	4	0.0101	
Sex x frequency	0.1366	3	0.0455	3.10	0.0369	3	0.0123	1.03
Frequency x treatment	0.7046	12	0.0587	3.99*	1.0818	12	0.0902	7.58**
Error	0.1769	12	0.0147		0.1422	12	0.0119	

*Significant at P = 0.05. **Significant at P = 0.01. ***Significant at P = 0.001.

sweeter products than did women and that children and adults over 50 liked sweeter foods better than did people in the middle-age brackets *(3, 5, 6, 10)*.

Effect of frequency of consumption. Table 4 shows that most families (46.2%) consumed commercially canned pears with a frequency of "several times per month." Home-canned pears were consumed with a considerably lesser frequency than commercially packed fruit. The frequency of use had a very highly significant effect upon the average scores, especially in the case of tasters of Santa Clara fruit. All the scores, as classified by frequency of consumption, follow the same general trend (Figure 2) i.e., a greater degree of liking for fruit with a soluble solids to acid ratio of between 138 and 171. However, higher scores were more often assigned to all the fruit by the more frequent users than by those who responded *infrequent* or *never*. This tendency is most apparent at the higher sugar levels where there are greater differences in the average scores between frequencies. The analysis of variance showed significant interactions between treatment and frequency of consumption (Table 4).

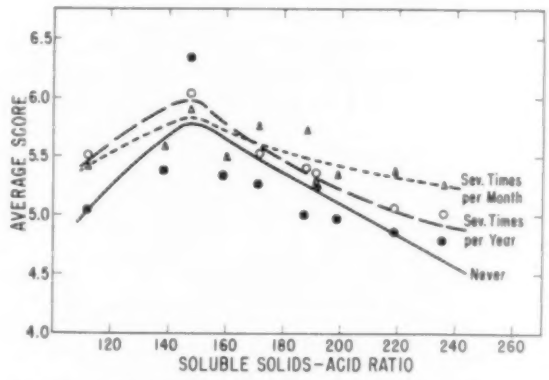

Figure 2. Frequency of use and average scores for canned pears, Redding 1957.

Effect of time of day. The pears were consumed most often after the evening meal and least often for breakfast. The effect of time of day on average scores was not significant (Table 5). Similar scores were obtained for the highest and lowest sweetness levels but

TABLE 5

Effect of time of day of tasting on average scores for canned Bartlett pears

Time of day	Santa Clara County						Lake County					
	Average no. individuals	Cut-out Brix					Average no. individuals	Cut-out Brix				
		18.5°	22.6°	26.3°	29.9°	32.7°		18.9°	22.8°	26.6°	30.6°	33.7°
Morning	55	5.65	5.24	5.28	5.31	5.28	40	5.44	5.81	5.57	5.00	5.42
Noon	115	5.65	5.63	5.50	5.32	5.41	108	5.43	5.83	5.52	5.34	5.38
Evening	411	5.71	5.78	5.60	5.37	5.41	409	5.46	5.98	5.58	5.38	5.23

Analysis of variance

Source	Degrees of freedom	Santa Clara County			Lake County		
		Sums of squares	Mean square	F ratio	Sums of squares	Mean square	F ratio
Total	29	1.3969			1.9923		
Treatment	4	0.4472	0.1118	3.69	1.4690	0.3673	81.62***
Time of day	2	0.2363	0.1182	3.90	0.0368	0.0184	4.08
Sex	1	0.0019	0.0019		0.0012	0.0012	
Sex x treatment	4	0.1872	0.0468	1.54	0.0397	0.0099	2.20
Sex x time	2	0.0653	0.0327	1.08	0.0470	0.0235	5.22*
Time x treatment	8	0.2165	0.0271		0.3627	0.0453	10.07***
Error	8	0.2425	0.0303		0.0359	0.0045	

*Significant at P = 0.05. ***Significant at P = 0.001.

there is a spread in the middle range (Figure 3). The tendency was to assign highest scores to pears tasted in the evening and the lowest to fruit evaluated in the morning, although the optimum soluble solids-acid ratio was consistently maintained. There were significant interactions for sex x meal and meal x treatment in the Lake County group.

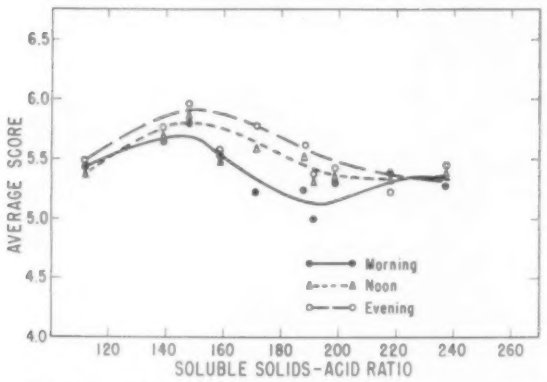

Figure 3. Influence of time of day on average scores, Redding, 1957.

Effect of body size. The heights and weights collected from the adults over 25 years of age were compared against standard tables of "ideal" weights *(2)*, then classified by percent deviation from the prescribed normal values. The body size distribution patterns were similar for the two populations with little difference between the sexes. The analysis of variance (Table 6) showed no significant differences between average scores attributable to variations in body size and no outstanding trends were observed. In a previous, smaller consumer study *(9)*, overweight consumers scored the very sweet fruit higher than did people who were underweight or of normal weight.

Effect of daily physical activity. The amount of physical activity engaged in during an average day (an estimate of bodily energy output), was classified according to the consumer's body size to give the following:

Body-Size	Number Individuals	Activity		
		Light	Moderate	Heavy
		%	%	%
Underweight	66	19.7	69.7	10.6
Normal weight	389	19.5	66.6	13.9
Overweight	215	21.4	62.8	15.8

The individual's physical activity had no influence on his degree of liking for the various sugar levels, as determined by this method. In addition, there appeared to be no relationship between body size and physical activity. Consideration must be taken of the fact that the figures obtained represent the individual's own estimate of his body height and weight as well as his particular concept of light, moderate and heavy activity.

Effect of tasting order. The dates on which the samples were tasted were recorded on the score cards, thus facilitating the determination of the effect of the samples upon each other in the order of sampling. These average scores are presented in Table 7 according to tasting order. Although the absolute magnitude of the difference appears to be large, there were no significant differences between average scores as a result of tasting order. An interesting observation was made pertaining to the influence of coding on the order in which many consumers tasted. The numerical identifications on the cans in order of increasing sugar content were "43," "81," "74," "59," and "65," respectively. More families (approximately 33%) tasted the canned fruit in increasing numerical order than in any other order. It is recommended, therefore, that sample codes (whether letters or numbers) be randomly assigned to treatments within each replicate.

Reasons given for responses. The reactions to quality factors the consumer liked and/or disliked are

TABLE 6

Effect of body size on average scores for canned Bartlett pears

Body size[1]	Santa Clara County						Lake County					
	Average no. individuals	Cut-out Brix					Average no. individuals	Cut-out Brix				
		18.5°	22.6°	26.3°	29.9°	32.7°		18.9°	22.8°	26.6°	30.6°	33.7°
1	30	5.31	5.63	5.62	5.58	5.48	36	5.30	5.97	5.33	5.64	5.19
2	214	5.69	5.67	5.54	5.28	5.16	209	5.45	5.93	5.70	5.28	5.18
3	88	5.72	5.51	5.49	5.20	5.21	82	5.35	6.00	5.57	5.14	5.24
4	28	5.45	6.24	5.57	5.32	5.15	21	5.95	6.09	5.18	5.60	5.58

[1] 1 = 1 to 15% underweight. 2 = Normal weight. 3 = 1 to 15% overweight. 4 = More than 15% overweight.

Analysis of variance

Source	Degrees of freedom	Santa Clara County			Lake County		
		Sums of squares	Mean square	F ratio	Sums of squares	Mean square	F ratio
Total	39	4.0700			5.4868		
Treatments	4	1.5674	0.3919	8.75***	2.0495	0.5124	4.44*
Body size	3	0.2100	0.0700	1.56	0.3650	0.1217	1.05
Sex	1	0.1232	0.1232	2.75	0.0010	0.0010	
Sex x treatment	4	0.2206	0.0552	1.23	0.2575	0.0644	
Sex x body size	3	0.5309	0.1769	3.48	0.3406	0.1135	
Body size x treatment	12	0.8806	0.0733	1.64	1.0880	0.0907	
Error	12	0.5373	0.0448		1.3852	0.1154	

*Significant at P = 0.05. ***Significant at P = 0.001.

TABLE 7

Effect of tasting order on average scores for canned Bartlett pears

Order of tasting	Santa Clara County					Lake County				
	Cut-out Brix					Cut-out Brix				
	18.5°	22.6°	26.3°	29.9°	32.7°	18.9°	22.8°	26.6°	30.6°	33.7°
First	5.84	5.77	5.59	5.39	5.29	5.79	6.16	5.44	5.59	4.78
Second	5.55	5.64	5.65	5.39	5.16	5.66	5.96	5.67	5.51	5.37
Third	5.19	5.63	5.54	5.57	4.95	5.31	5.97	5.49	5.40	5.02
Fourth	5.65	5.75	5.24	5.21	5.51	5.21	5.80	5.57	4.64	4.97
Fifth	5.71	5.65	5.88	5.04	5.37	5.24	5.86	5.65	5.36	5.23

Analysis of variance

Source	Degrees of freedom	Santa Clara County			Lake County		
		Sums of squares	Mean square	F ratio	Sums of squares	Mean square	F ratio
Total	24	1.5188			3.3132		
Treatment	4	0.7162	0.179	4.17*	2.1283	0.532	11.57***
Tasting order	4	0.1121	0.028		0.4420	0.111	2.40
Error	16	0.6905	0.043		0.7429	0.046	

*Significant at P = 0.05. ***Significant at P = 0.001.

shown in Table 8. For both sets of pears, flavor was the characteristic most frequently mentioned. This observation corresponds to results reported by other investigators. Gould, *et al. (1)* stated "The attribute of quality which was most important to the (consumer) panel and most closely associated with overall preference of a commodity was flavor." The flavor of the pears was most liked at the 40° in-going Brix level, and was liked less with a subsequent increase in sugar. The per cent response for liking of flavor and sweetness almost parallel when plotted against soluble solids to acid ratios (Figure 4). These data further substantiate the positive association between the two characteristics in the minds of the consumers.

When asked to state the factors they disliked, fewer than 12% mentioned flavor, even at the higher sweetness levels (Table 8). The sweetness of the pears at the higher sugar concentrations was disliked by approximately half of the tasters. Consistent with the foregoing, the apparent acidity at the lower sugar levels was liked better than at the higher sugar concentrations. Remarks on texture and color were virtually unaffected by the increasing sugar content. In a previous survey on apricots *(9)*, consumers found an improved texture and color with increasing amounts of sugar.

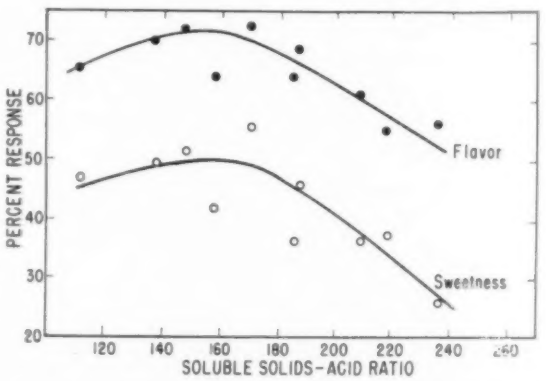

Figure 4. Consumer opinions on flavor and sweetness in canned pears (factors liked) Redding, 1957.

Opinion of commercially canned pears. Table 9 summarizes the consumers' responses to inquiries on purchase of commercially canned pears. Of the 378 families responding, 7.4% reported they never bought

TABLE 8

Consumer reaction to quality factors in canned Bartlett pears

	Santa Clara County					Lake County				
	Cut-out Brix					Cut-out Brix				
	18.5°	22.6°	26.3°	29.9°	32.7°	18.9°	22.8°	26.6°	30.6°	33.7°
Number of tasters	590	579	581	594	580	555	547	564	566	549
Average score	5.68	5.69	5.55	5.36	5.23	5.45	5.94	5.55	5.32	5.23
	Percentage[1]									
Factors liked										
Flavor	70.2	73.2	68.7	60.6	56.2	65.4	78.2	62.6	62.5	54.5
Texture	40.2	43.4	43.5	42.4	40.5	36.9	55.8	46.5	43.1	44.1
Color	45.9	50.6	44.4	43.3	46.2	42.0	48.4	45.4	42.8	39.7
Sweetness	49.5	55.1	45.1	36.5	25.5	45.9	50.3	42.4	36.6	38.6
Acidity	11.0	10.2	7.1	4.7	5.3	7.6	12.2	7.4	7.6	3.3
Factors disliked										
Flavor	11.9	8.8	9.6	11.4	11.2	17.3	7.1	9.2	9.5	11.7
Texture	25.4	27.5	24.1	25.9	26.3	36.8	15.7	28.5	24.7	19.7
Color	4.4	5.2	4.3	5.7	3.9	4.1	3.3	2.7	2.5	4.4
Sweetness	17.1	15.9	29.6	45.8	53.3	17.3	19.0	32.6	44.9	54.1
Acidity	4.6	3.5	3.4	3.5	3.3	5.1	3.5	3.5	2.1	2.9

[1] Figures may total more than 100% because of multiple answers.

TABLE 9

Frequency of use of commercially canned pears and reason for purchase

	Never buy	Brands purchased				
		"A"	"B"	"C"	"D"	Others
Families						
Total number	27	179	50	24	22	128
Percentage	7.4%	48.9%	13.7%	6.6%	6.0%	35.0%
	Percentages[1]					
Frequency						
Several times per week	....	8.9	6.0	25.0	9.1	14.8
Several times per month	....	44.7	48.0	37.5	72.9	43.0
Several times per year	....	44.7	42.0	33.3	18.0	42.2
No answer	....	1.7	4.0	4.2	0	0
Reason for buying						
Taste	....	67.6	70.0	66.6	86.4	53.9
Price	....	17.8	20.0	66.6	13.6	58.6
Availability	....	29.1	28.0	45.8	36.4	25.0
Habit	....	46.9	36.0	20.8	27.3	15.6
Other	....	18.4	16.0	8.3	0	11.7
No answer	....	1.1	2.0	0	0	7.0

[1] Figures may total more than 100% because of multiple answers.

canned pears. Almost 50% bought brand "A," mostly because of flavor (67.6%) and habit (46.9%). Flavor and habit were reasons most often given for buying brand "B" whereas the purchase of "C" was determined by taste and price equally. Price was the most influential factor in the purchase of the 8 brands listed under "others." Several consumers of brands "A" and "B" stated that dependability of the brand from commodity to commodity and uniformity of quality from can to can influenced their purchases.

Available commercially canned pears mentioned by the consumers were purchased from various Redding markets and brought to the Food Technology Department for laboratory evaluation and chemical analyses. Table 10 summarizes the findings obtained. The sample designated as "F" was thought to be much superior in flavor quality than all the others; yet it was too soft in texture. Samples "A" and "B" rated first and second, respectively, by the consumers, placed second and third, respectively, in the laboratory panel's degree of liking.

Effect of repeated evaluation. Since the difference between mean daily temperatures for the month of February (min. 44°; max. 63° F.) and the month of August (min. 63°; max. 113° F.) were smaller than anticipated, it is not known whether the differences in average scores between the 2 months were the result of climatic variation. However, the data obtained in

TABLE 10

Laboratory evaluation of commercially canned pears

Brand	Cut-out Brix	pH	Total acidity	Brix-acid ratio	Average score[1,2]
			%		
A	20.44	4.00	0.136	150.3	5.52
B	20.53	4.01	0.190	108.1	5.22
C	19.22	4.27	0.129	149.0	4.60
D	15.28	4.30	0.104	146.9	4.53
Others[3]					
E	19.39	4.03	0.145	134.6	4.73
F	15.01	4.09	0.141	106.5	5.60
G	23.50	3.93	0.190	123.7	4.46
H	18.39	3.88	0.220	83.6	4.33

[1] Scored on a 7-point hedonic scale.
[2] Average of 15 judgments.
[3] Four out of 8 minor brands mentioned by the consumers.

August were considered useful in testing the effect of repeated testing on the consumers' responses. Attention is called to the fact that for fruit from both growing areas, the middle and the highest sugar levels were better liked in August than in February (Table 11). However, the only significant difference obtained (by applying Student's t-distribution for paired variates) was between average scores for the middle sugar level of the Lake County fruit. It can be concluded that reproducible results were obtained from the consumers interviewed.

SUMMARY

Bartlett pears differing in total acidity were canned with sugar syrups of 30°, 40°, 50°, 60°, or 70° Brix then evaluated by 378 families in Shasta County, California. Using a hedonic scale of 7 descriptive terms and single sample presentation, the consumers found a soluble solids-acid ratio of between 138 and 171 as most acceptable. Fruit with high acidity (approx. 0.160% citric) was liked best with a sugar content of 22.8° Brix whereas pears with low acidity (approx. 0.135% citric) were liked equally well at 18.5° and 22.6° Brix levels.

No significant differences in average scores were observed between males and females; however, the participants under 16 and over 50 years of age tended to prefer the sweeter pears as well as to assign higher scores to all the samples. Consumers who tasted pears in the evening assigned higher scores than noon or morning tasters. Also, higher values were given to the fruit by the more frequent consumers of the product. There were no significant differences between average scores attributable to body size, physical activity, or to the order in which the samples were

TABLE 11

Consumer response to canned pears in winter vs. summer

	Lake County					Santa Clara County				
	In-going Brix					In-going Brix				
	30°	40°	50°	60°	70°	30°	40°	50°	60°	70°
No. families	42	42	39	43	42	34	33	36	34	35
Average score										
February[1]	5.53	5.90	5.57	5.29	5.11	5.87	5.76	5.39	5.49	5.11
August[2]	5.23	5.73	5.70	5.22	5.18	5.58	5.76	5.46	5.35	5.21
Significance			***							

***Sig. at P = 0.001.
[1] Average temperatures in Redding for the month of February, 1957 was min. 44°; max. 63° F.
[2] Average temperatures in Redding for the month of August, 1957 was min. 68°; max. 113° F.

tasted. Reproducible results were obtained from the re-testing of 100 families after a period of 6 months.

Flavor was the most frequently mentioned attribute of the experimental pack as well as the reason most often given for purchase of commercially canned pears. The data showed the consumers' positive association between sweetness and pear flavor. Texture and color were apparently unaffected by the sugar levels employed.

Acknowledgments

The chemical analyses of the canned pears are credited to Dr. Bor S. Luh and his students. The authors are indebted to Miss Mary Lin Maxwell, Miss Susan Martin and Mrs. Janella Boswell for assistance in conducting the survey. Appreciation is extended, also, to Mr. Francis Smith, Shasta County Farm Adviser.

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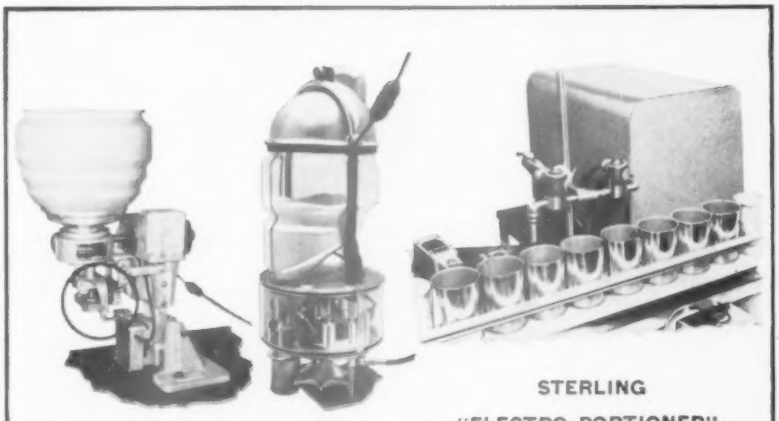

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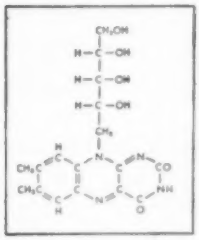
The Vital Story

A Quick History. Independent investigators, working separately to unlock several of nature's doors, sometimes open up unsuspected relationships. This happened with vitamin B_2.

Investigations. About 25 years ago, several groups, notably Warburg's, were investigating a "yellow enzyme" obtained from yeast. Almost simultaneously other investigators were studying a food factor that aided growth of laboratory animals.

What they found. Proceeding with chemical analysis of this growth factor, the team of Kuhn, György, and Wagner-Jauregg noted a relationship between the growth-producing agent and the "yellow enzyme." Their findings, and those of other researchers along similar lines, were published in 1933. Eventually, riboflavin and an essential part of the yellow enzyme were found to be identical and the unity of an essential nutrient and cellular metabolism was established.



Isolation of pure riboflavin was achieved by Kuhn and his co-workers, and by Ellinger and Koschara, in 1933.

Nomenclature. Known in the United States as riboflavin, this vitamin has also been called lactoflavin, ovoflavin, hepatoflavin, and vitamin G.

SYNTHESIS

By 1935, two eminent chemists, working separately, had synthesized riboflavin, practically in a dead heat. Prof. Paul Karrer of the University of Zurich, a collaborator of the Hoffmann-La Roche Laboratories, produced the first successful synthesis. Five weeks later Richard Kuhn of Germany announced his synthesis of the vitamin. Prof. Karrer subsequently shared the Nobel Prize in Chemistry for his work in vitamins and carotenoids.

The Karrer synthesis forms the basis for chemical processes in widespread use today by Hoffmann-La Roche and other leading manufacturers throughout the world. Riboflavin is also manufactured today by fermentation methods.

CHEMICAL AND PHYSICAL PROPERTIES

Riboflavin is yellow, slightly water-soluble with a greenish fluorescence and a bitter taste. Its empirical formula is $C_{17}H_{20}N_4O_6$. Vitamin B_2 produced by the Roche process is identical in every way with that occurring in nature.

How does vitamin B_2 work? Riboflavin is a vital part of nature's chain of reactions for utilization of carbohydrate energy. It has been found to be a constituent of many enzyme systems and is thus intimately connected with life processes. It is probably required by the metabolic processes of every animal and bird as well as by many fishes, insects and lower forms of life. (In certain animals, however, the requirement may be synthesized by bacteria within the intestine.)

In the cells riboflavin goes to work attached to a phosphate group. This substance, known as riboflavin-5′-phosphate or flavin mononucleotide, may in turn be attached to still another essential substance, adenylic acid, forming flavin adenine dinucleotide. Either nucleotide then is attached to protein, thereby forming an enzyme, and takes its part in oxidation-reduction reactions.

Requirements in Human Nutrition. As we have seen, vitamin B_2 is essential to life. We have no special storage organs in our bodies for this vitamin, although a certain level is maintained in various tissues, with relatively large amounts found in the liver and kidneys.

MEASURING METHODS

In the beginning, riboflavin activity was described in "Bourquin-Sherman units" and requirements were thought to be very small. Subsequent research showed otherwise. Milligrams of weight became the unit and the Food & Drug Administration of the U. S. Dept. of Health, Education & Welfare established (July 1, 1958) a minimum daily requirement of 1.2 mg. of riboflavin for all persons 12 or more years old. For infants it is 0.6 mg. These requirements are designed to prevent the occurrence of symptoms of riboflavin deficiency disease. The minimum daily requirement for this vitamin for children from 1 to 12 years is 0.9 milligram.

Recommended allowances. The Food & Nutrition Board of the National Research Council has recommended the following daily dietary allowances of riboflavin, expressed as milligrams. These are designed to maintain good nutrition of healthy persons in the U. S. A.

Men			1.6
Women			1.4
"	(3rd trimester of pregnancy)		2.0
"	(Lactating)		2.5
Infants,	1-3 months		0.4
"	4-9 "		0.7
"	10-12 "		0.9
Children,	1-3 years		1.0
"	4-6 "		1.2
"	7-9 "		1.5

		Boys	Girls
Adolescents,	10-12 years	1.8	1.8
"	13-15 "	2.1	2.0
"	16-20 "	2.5	1.9

# of VITAMIN B_2

(Riboflavin)

by Science Writer

Deficiencies of vitamin B_2 appear in several ways in human beings. The eyes, the skin, the nerves, and the blood show the effects of too little riboflavin. Laboratory animals have demonstrated that a riboflavin-deficient diet can cause death of adults and can slow or stop growth in the young. Female animals, deprived of riboflavin in the diet, may produce offspring with congenital malformations.

Medical uses. To overcome and control deficiencies in human beings, physicians have pure riboflavin available for administration by injection or orally, by itself or with other "B" vitamins or multi-vitamin-mineral combinations.

How do we get our daily riboflavin? Vitamin B_2 has wide distribution throughout the entire animal and vegetable kingdoms. Good sources are milk and its products, eggs, meats, legumes, green leaves and buds. Whole-grain cereals have significant but not large amounts of riboflavin.

ADDITION TO FOODS

Cereal foods play a large part in our diet. To produce the white flour almost all of us want, millers are obliged to remove parts of the wheat that contain much of the grain's riboflavin and other nutrients. In addition, cereal grains are not rich sources of riboflavin. Millers meet this problem by *enriching* the grain foods for which federal standards exist with vitamins B_1, B_2, niacin and the mineral iron. In the case of vitamin B_2, however, they do more than *restore* the processed food to its natural riboflavin level; they *fortify* the food with enough of this essential vitamin to make it nutritionally more valuable than it was in nature.

Acting to protect the good health of millions of Americans, bakers and millers adopted *enrichment* of white bread and white flour in 1941. Since that time, other foods, such as macaroni products, corn meal and grits, farina, pastina and breakfast cereals have had their food value increased by enrichment with pure riboflavin and other vitamins and minerals.

When enriching, fortifying or restoring, food manufacturers add the necessary quantity of riboflavin (and other vitamins and minerals) to the food during processing, so that the finished product meets federal, state, and territorial requirements or contributes to the consumer an amount of the vitamin that dietary experts believe significantly useful.

PRODUCTION

Prof. Karrer's synthesis of riboflavin was a laboratory success. Adapting the process to commercial production, however, demanded original thinking by chemists at Hoffmann-La Roche. The production of riboflavin by chemical synthesis requires the production of ribose, a rare sugar, at an early stage in the process. This special sugar must be made inexpensively if the synthesis is to be practical. Sugar chemistry is a difficult matter. In a brilliant piece of work, the Roche chemical experts developed a method to produce ribose on a commercial scale by an electrolytic process, thus overcoming a most troublesome problem. Subsequently, Roche chemists developed the first practical synthesis for riboflavin-5′-phosphate, identical with natural flavin mononucleotide.

Picture three streams joining to form a river and you have a simplified idea of the Roche process for synthesizing vitamin B_2. O-xylene and glucose are processed separately to form xylidine and ribose respectively. These are joined to form ribitylxylidine, which is then converted to ribitylaminoxylidine. Starting separately with malonic ester, which is processed through intermediate stages to alloxan, the third "stream" is then joined with ribitylaminoxylidine to form riboflavin. Purification occurs at each step of the synthesis. Riboflavin 'Roche' equals or exceeds U. S. P. standards.

By the tons. So efficient is the Roche process that pure riboflavin is produced *by the tons* for use in pharmaceutical products and processed foods. An interesting development by Roche is the production of riboflavin in different forms related to the method of end use. 'Roche' Regular riboflavin U. S. P. is especially useful in dry enrichment premixes, powdered dietary supplements, pharmaceutical tablets and soft gelatin capsules. 'Roche' Solutions type is preferred for the manufacture of solutions having low concentration. 'Roche' Riboflavin-5′-Phosphate Sodium is a highly and rapidly soluble riboflavin compound favored for all pharmaceutical liquid products and some tablets, lozenges, and capsules. It has a more pleasant taste than the bitter U. S. P. riboflavin.

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Objective Tests of Quality in Wheat and Wheat Products*

M. A. Barmore

U. S. Department of Agriculture, Western Wheat Quality Laboratory, Department of Agricultural Chemistry, Agricultural Experiment Station, Pullman, Washington

(Manuscript received December 12, 1957)

QUALITY IS A TERM applied to wheat and flour to indicate suitability for the intended food uses. There are two subdivisions of the term wheat quality. The first is the sense in which quality is used by the grain marketing trade to refer to the physical condition of grain—that is, freedom from trash, insects, other seeds, excessive moisture, mustiness, mold, etc. The second meaning is that used by the cereal chemists to describe the suitability of wheat to produce flour that will make desirable baked products at a minimum cost—the meaning as the term is used in this paper.

There is no need to dwell on the size of the wheat crop nor the importance of the products made from wheat. The evidence is in the daily papers and on everyone's table. Testing, purchasing, grinding, selling, and using the flour of over 500 million bushels of wheat each year is a major industry. But in spite of this volume of business, and the age of the industry, the determination of quality is still rather indefinite.

There are essentially two groups of cereal chemists working on wheat quality; namely, those at work in the milling and baking industry and those working with the wheat breeders. Quality must of necessity be measured in much the same way by both groups, but the second group has the added problem of determining the quality of small samples of wheat or flour. The present discussion of wheat quality problems is made from the point of view of the chemist associated with wheat breeding.

About 125 plant scientists, working for the State experiment stations or for the United States Department of Agriculture, are endeavoring to develop new varieties of wheat that will be better suited to their local conditions—that is, to their local soil types, winter and summer temperatures—and resistant to prevalent insects, diseases, storms, drouth, etc. The plant scientists have worked out test methods for suitability to meet these production hazards, but the task of determining how well their new selections will meet the requirements of the miller, baker, and consumer has been assigned to the cereal chemist.

Wheat improvement projects, in view of the current wheat surplus, might seem to be somewhat illogical, but there is no argument against increased efficiency in the production and processing of a major crop. Increased efficiency through better yields per acre and improvements in milling and baking characteristics of wheat and flour benefit everyone concerned. Our surplus problem is separate from wheat improvement and it would not be intelligently solved by inefficiency.

Many food products are made from wheat. The conversion of wheat to flour and the conversion of the flour to edible products involve considerations of quality all along the line.

The first phase of quality concerns milling or the conversion of wheat into flour or into semolina. The wheats that have the highest milling quality are generally those which can be converted into flour at the least expense to the miller. Therefore, those wheats which mill the most rapidly and yield the largest amount of flour containing the least bran and shorts have the highest milling quality. The method of measuring these factors, used by this laboratory, consists primarily of a small-scale conventional flour mill (Figure 1). As illustrated in this figure, the

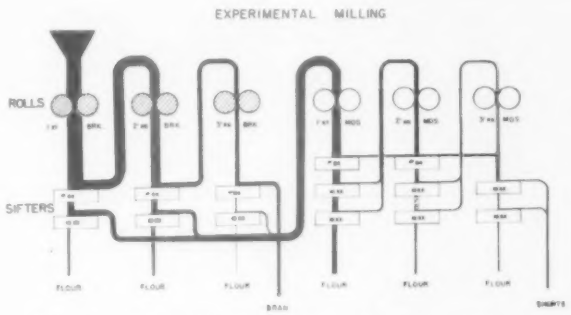

Figure 1. Schematic flow diagram of experimental milling procedure.

grain enters the machine at the upper left, passes through the corrugated rolls (the lined circles), drops on a vibrating screen with 44 wires per inch followed by one with 100 threads per inch. The width of the routing lines represents the percentage of the original wheat stream in the various stages of the process. The "overs" of the 44 wire sieve are elevated to the second pair of rolls (set slightly closer together) reground, resieved, and routed as shown. The "thrus" of the 44 wire are sieved on a 10XX flour cloth—the "overs" elevated to the smooth rolls (the open circles), ground, sieved, and routed as shown. The "thrus" of a 10XX constitute one "flour stream." All flour streams are combined for most variety quality determinations.

The most important features of the milling unit are the corrugated and smooth rolls (Figure 2), and

* Cooperative investigations by the Crops Research Division, ARS, USDA, and the Washington Agricultural Experiment Station.

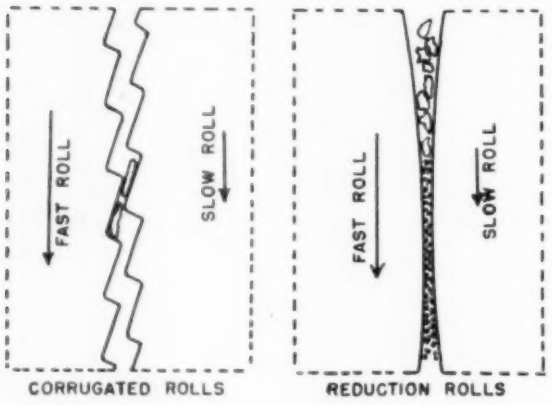

Figure 2. From reference 10. Cross section view of milling rolls in the grinding zone.

the fact that one roll of each pair runs about twice as fast as the other. This produces a scraping as well as a crushing action, which makes possible the gradual separation of endosperm from bran and shorts [b] (Figure 3). Here the relative locations of the three primary portions of the kernel are shown—the endosperm, which is converted to white flour, and the germ and bran portion which are separated from the flour.

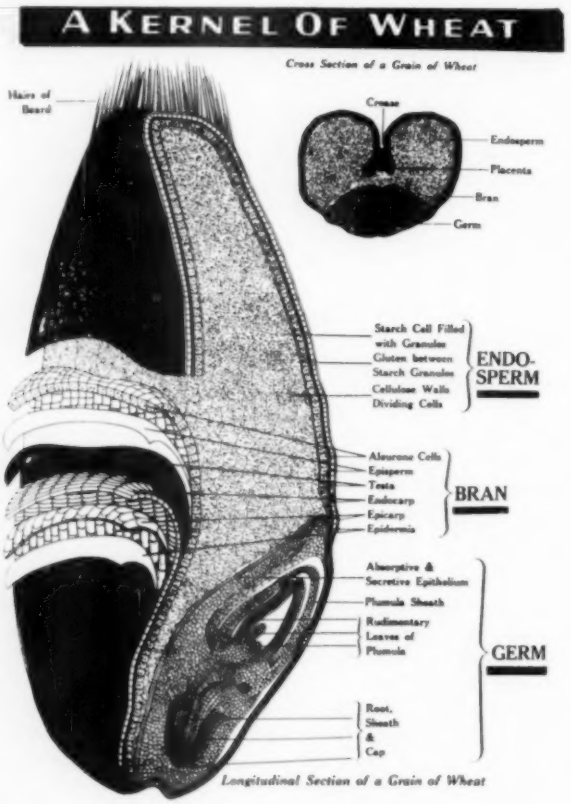

Figure 3. Dissected view of wheat kernel.

[b] Endosperm cell wall, fine bran, germ and unseparable endosperm.

The most important measurable milling factors, as relating to quality, are rate or time required in milling the wheat and yield of white flour. Flour sells for 6 to 8 cents per pound; bran and shorts sell for 2 to 3 cents per pound. Wheats differ by as much as 25% in the rate of milling. These and other measurable factors, such as ash content, yield of the best grade of flour, and the moisture content required for optimum milling condition, have been combined into a single value, called the milling score. This is:

$$\text{Milling Score} = 100 - [(80 - \%\ \text{yield}) + 50\ (\%\ \text{ash} - .30) + .4(\text{milling time} - 15) + .2(65 - \%\ \text{long patent}) + .5(16 - \%\ \text{milling moisture})]$$

This means that anything less than an 80% total flour yield, 65% yield of long patent flour (the best grade of flour) and 16% milling moisture or more than .30% ash or 15 minutes to mill a 2400 g. sample is subtracted from 100 and called milling score. The scores obtained for the Pacific Northwest commercial varieties are listed in Figure 4 with the best milling types at the left.

Adequate data to calculate milling score can be obtained from a 5-pound sample. However, it takes several generations following a cross for the selection of suitable plant and quality characteristics, but 10,000 third-generation lines can be produced from a single crossed seed. The production of 5 pounds of grain of each selected line with the best agronomic characteristics requires a large number of plants and a considerable amount of sowing, harvesting, and threshing. Consequently, plant breeders have been asking for quality tests applicable to the grain from a single plant. As a result of studies along this line, a method and machine have been developed by this laboratory and the Division of Industrial Research, Washington State College, to obtain a preliminary measure of the ease of separation of endosperm from bran. This is accomplished by using 5 g. of grain—or less than the amount of grain obtained from a single plant. Two people can mill 10 to 15 samples of 5 pounds each in an 8-hour day on a conventional experimental flour mill. With the use of the 5-g. micro mill, two people can mill as many as 1,000 samples in the same length of time.

Milling quality appears to be related in part, at least, to the ease of separation of bran from endosperm. This in turn appears to be related to the endosperm cell wall thickness, a phenomenon discovered by the Agricultural Research Service laboratories in Albany, California *(5)* and at Peoria, Illinois *(8)*. These cell walls are high in hemicelluloses and their thickness is measured by the amount of pentosan in the wheat. Thus, pentosan content appears to be a measure of an important milling factor. This cell wall material appears to react much like tough paper when run between grinding rolls. That is, it "fluffs up" and decreases the bulk density of the milling stocks which, in turn, reduces the rate

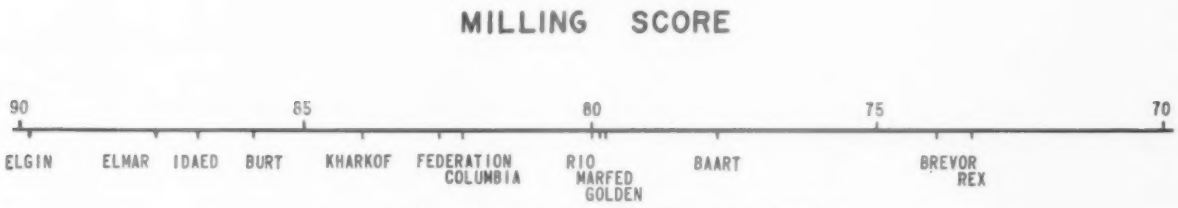

Figure 4. Milling score of Pacific Northwest wheat varieties.

of sieving and thus the rate of milling or the amount of flour obtained.

Of the 20 billion pounds of flour consumed each year in the United States, 18 billion pounds, or 88% is white flour. White flour is used for making white bread, biscuits, crackers, cakes, pies, doughnuts, etc. These different types of products require different protein levels (Table 1).

TABLE 1

Percent protein required for various types of flour used for baked products

Type of flour	Protein percent
Hearth or Panless Bread	12.5–15.0
White Pan Bread	10.4–12.0
Family Flour (Retail)	9.5–10.5
Biscuit and Cracker	7.5–10.0
Cake, Cookie, Piecrust	7.0– 9.0

Wheats of about 1% above the flour protein must be used in making flour of these protein levels. Table 2 illustrates the range in protein content available to Pacific Northwest millers. This table is a compilation of the number of samples analyzed by Pacific Northwest cereal chemists during the summer harvest season of 1956 and found to have the per cent protein in the range indicated at the column headings. The principal varieties or types of wheat and the use of flour for various products are also shown. The wide variations in protein content among the wheats are due largely to differences in such factors as precipitation, soil types, summer temperatures, cultural practices, and fertilizer treatments in the different areas of production. Meeting the protein requirements of a flour for the production of certain baked products is a problem, but there are other flour properties which must be attained at the same time. These could be partly met by specifying wheat variety, but variety identification of threshed grain is extremely difficult and at the present time impractical.

The biggest proportion of the white flour used in the United States is employed to produce white bread. This is the principal reason why most of the quality work has dealt with bread flours. But in spite of all the work that has been done, there are still no analytical methods of determining the quality of flour for bread other than the generally accepted determination of protein nitrogen.

Besides having a protein content of 10.4 to 12%, a suitable white bread flour must be capable of: absorbing a relatively large amount of water, developing rapidly to a pliable, elastic dough on mixing, tolerating extended mixing, tolerating fermentation, and producing a large loaf of bread with satisfactory crumb color, grain and texture.

The most important property, loaf volume, is determined by one or more of several small-scale baking methods. These baking methods approximate the commercial bread-baking processes in proportions of ingredients and procedures. They are on a scale of 100 g. of flour. The baking is done with experimentally milled flour which is almost invariably treated with various amounts of potassium bromate to take the place, at least in part, of the bleaching or maturing treatment which is applied to nearly all commercial bread flours.

There is a considerable difference of opinion relative to the best proportion of ingredients and the best mixing and fermentation time. However, most cereal chemists concerned with wheat breeding believe that the best test of the bread-baking character of a flour is measured by the *best* loaf of bread that can be produced from it. Therefore, it is general practice to mix flours to their optimum dough condition, to introduce the proper amount of water to form a dough of the proper consistency, to include dried milk solids and shortening and to use the right amount of potassium bromate, to produce the optimum loaf possible for the sample of flour under examination. Anything less than such a procedure overlooks the capabilities of the flour that will be brought out by intelligent commercial practice.

Mixing characteristics of the flour are measured by noting the time required to mix the water and other baking ingredients to produce a smooth elastic dough without stickiness. Recording mixers are also used to record mixing properties. There are two common types—the Brabender Farinograph and the National Mixograph. Both are capable of recording elastic or plastic forces continuously during a mixing period—which may vary considerably among different flours. The mixing time determined by the two recording mixers is the length of time required to reach the maximum development or height of the curve. Satisfactory and poor mixing flour types from each of these machines are shown by the curves in Figure 5. The mixing record starts at the lower left corner of each chart. The plastic or consistency factors are recorded in the vertical direction and time in the horizontal direction. The poor curves show the short time required to reach maximum consistency followed by the much more rapid reduction in consistency and lower final value after an equal amount of additional mixing.

TABLE 2

Wheat crop survey by Pacific Northwest Crop Imp. Assoc. and Pacific Northwest Section Amer. Assoc. Cereal Chemists

Use		Variety or type	Number of samples with indicated percent of protein											
			6.0–6.9	7.0–7.9	8.0–8.9	9.0–9.9	10.0–10.9	11.0–11.9	12.0–12.9	13.0–13.9	14.0–14.9	15.0–15.9	16.0–16.9	17.0–17.9
Biscuit & cracker	Bread	Turkey	....	4	54	125	315	394	538	413	223	110	31	6
		Henry	....	....	2	2	5	10	4	2	....	1	....	....
		Baart	....	....	....	35	228	374	325	218	63	7	2	....
		Idaed	....	....	2	43	60	67	39	6	1	1	....	....
	Pastry	Federation	1	8	9	126	213	117	5	3	1	....	....	....
		Fortyfold	....	23	14	9	9	5	....	....	....	....	....	....
		Club types	22	170	284	215	113	36	3	3	....	....	....	....
		Brevor	....	13	48	49	30	3	2	1	....	....	....	....
		Marfed	....	2	18	30	49	31	15	....	5	....	....	....
		Lemhi	....	1	14	185	269	62	7	3	3	....	....	....

The absorption is the amount of water the flour will absorb to produce a smooth, elastic dough without stickiness *(6)*. Absorption is also measured by the amount of water required to produce a specified degree of consistency or plasticity in a dough, as measured by the height on the farinograph curve.

Sound wheat contains some natural diastatic enzymes, but generally an insufficient amount for the baking of commercial bread. The natural content of the flour, as well as that of the enzyme fortified flour, should be measured. One method measures the degree of starch liquefication in a recording plastimeter as the flour suspension is being heated slowly from room temperature to 95° C. *(9)*. An older, chemical method measures the amount of maltose or reducing sugar produced in one hour of digestion at 30° C. *(1)*.

Fermentation tolerance may be measured by baking a series of loaves with varying fermentation times, measuring loaf volume, and judging the loaves for internal characteristics.

Indirect methods related to the ability to produce a large loaf volume with acceptable external and internal characteristics are the sedimentation *(14)* and dough expansion tests *(11)*. The basis for the sedimentation test is that the better bread flours will swell more in weak lactic acid than the less suitable flours. The test consists essentially of the determination of the volume occupied by the flour which settles out of a weak acid suspension after hydration. The expansion test is based on the ability of the flour dough to hold carbon dioxide gas formed by yeast. The better bread flours hold a larger proportion of the gas.

As stated before, the largest portion of our white flour is used for white bread. The second largest portion, classed as pastry flour, is made from soft wheat. The measurement of quality for this class of flour is in a much less developed stage than for the bread flours. To add to this state of confusion, there are a number of uses of pastry flours—such as for cookies,

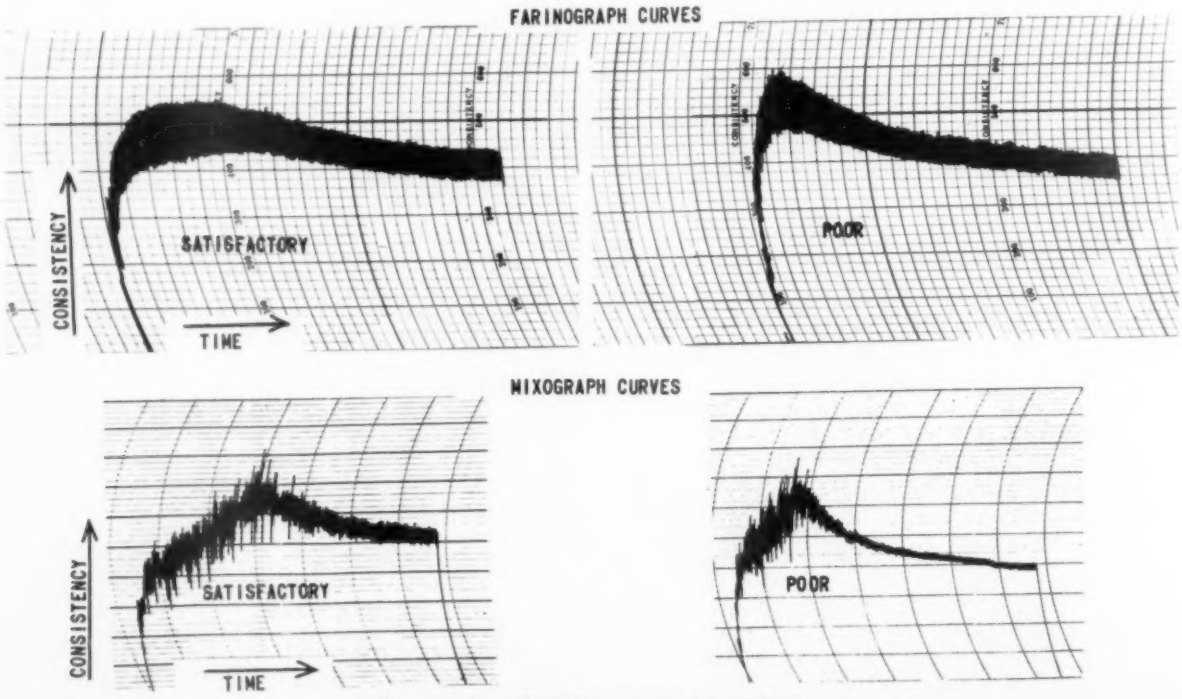

Figure 5. Recording mixer curves of bread flours.

pies, and cakes. Each use requires different properties; whereas bread flour is somewhat standardized.

Probably the best measure of pastry flour quality is the cookie baking test *(7)*, a small-scale baking test producing hard or crisp cookies by conventional baking procedures. In the terms of the weight of the flour used, the formula includes, by weight, 60% sugar, 30% shortening, and 3% dried skim milk. The "softest" pastry flours produce the largest sized cookies. Cookie appearance seems to be of little importance, as the top grain appears to be a function of the diameter of the cookies.

Cake baking methods are also used, but there is no generally or widely adopted procedure. The cake must be judged for internal characteristics as well as be measured for volume. Volume is important but not more important than internal texture and grain. Scoring methods are available, but there is no widely accepted score card. Flours should be bleached with chlorine for cake making, but to date this treatment is not satisfactorily controlled on experimentally milled flours.

The viscosity test is a useful test for pastry flour quality. This is measured in a lactic acid suspension of flour by means of a MacMichael viscosimeter *(1)*. Pastry flours vary in viscosity from very low values to medium values, depending on their uses *(3)*.

Absorption, as in bread flours, is the amount of water required to make a dough of the proper consistency without stickiness. For pastry flours low absorptions are preferred *(6)*.

Another empirical indication of pastry flour quality is known as its mixing curve area *(4)*. This is the area under the curve produced by the Mixograph run for a fixed period of time. Figure 6 shows two of these curves. The best pastry flours change very little in elasticity from the beginning to the end of the mixing period and enclose a smaller area in the curve.

Still another more empirical test for pastry flour quality is alkaline water retention capacity, which is essentially a measure of the amount of water that can be absorbed and held against centrifugal force by a flour in a weak alkaline (sodium bicarbonate) solution *(13)*. The softer pastry flours retain the least amount.

Wheat breeders are interested in estimating flour quality of the grain from single plants. Since the previously described flour tests require from 10 to 100 g. of flour per replication, effort has been expended to develop micro tests for flour quality. Bread making methods requiring only 10 g. of flour have been developed and used, but that is more flour than can be obtained from most single plants *(12)*. Promising micro sedimentation, expansion and mixing tests have been developed,[c] using from .2 to .5 g. of wheat meal.

Additional wheat products made in considerable volume are macaroni, spaghetti and other paste products. These are made from durum wheat, a hard white (amber) wheat of spring habit grown mainly in the Dakotas. The endosperm of this type of wheat

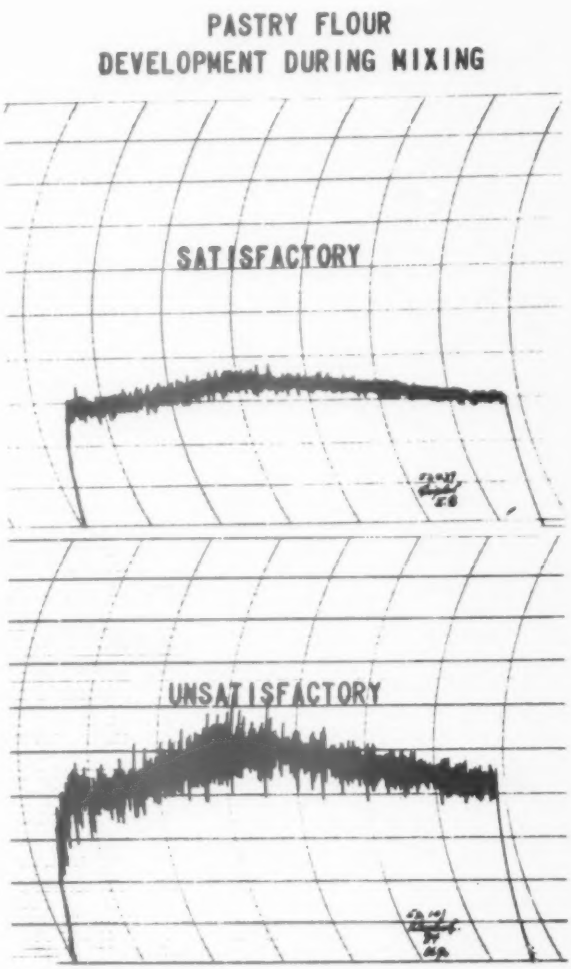

Figure 6. Mixograph recording mixer curves of pastry flours.

is milled into semolina by separating the bran and shorts by conventional wheat milling equipment, using corrugated rolls and coarse sieves. Any flour produced is sifted out of the coarser semolina. The semolina is mixed with water to form a stiff dough, further worker by passing it several times through pairs of cog-type kneading rolls, folding between passes. In one method the dough is then cut into discs about ⅛ in. thick, subjected to pressure up to about 1,500 p.s.i. for a few minutes to coalesce fine air bubbles, and then dried slowly. Another method consists of a similar application of pressure for a short time, followed by extrusion as macaroni, and slow drying under controlled conditions. The product is examined for opacity and yellowness by visual inspection or photometrically. Quality is proportional to the degree of transparency and yellowness, without greyness or redness *(1)*.

One of the major variables in wheat and flour is the protein content (Table 2). It has been found that absorption, loaf volume, sedimentation, viscosity, and cookie diameter in western American varieties are influenced significantly by protein content.

[c] As yet unpublished.

Because of this relation, appropriate adjustments for protein content can be applied to the above-enumerated components of quality. Thus, it is possible to eliminate the protein variable to a considerable extent. By means of punch cards and machine computation, it has been possible to calculate correction factors for the common western varieties and to calculate, at fixed protein levels, the best estimate of many of the objectively measured quality components. These calculations have been made for each variety and each quality component. Resulting values have been arranged in decreasing order of suitability on scales of uniform length, and are shown side by side for both bread and pastry type flours *(2)*. These constitute a concise summary of the quality characteristics of the common commercial varieties grown in the Pacific Northwest. Similar calculations for new selections being considered for release make it possible to compare their properties with those of the current commercial varieties and in this manner to determine their suitability.

It is believed that other types and varieties of wheat can be classified in a similar manner and that as other objective measures of quality are developed they can be included in this method of describing wheat varieties. The method is not conclusive or perfect, but it does summarize a large amount of quality data briefly, accurately, and in a way whereby it can be and is being used by wheat breeders and the milling industry.

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Effect of Delayed Handling Upon Shrimp Quality During Subsequent Refrigerated Storage

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DETERIORATION of seafood quality is considered generally to result from the action of enzymes from either the tissue or contaminating microorganisms. Spoilage of the product, however, is believed to be mainly the result of bacterial action, and is due to the consequent formation of compounds which impart off odors, colors and flavors. Young *(12)* recently pointed out that during the critical period between the time fish are killed and are actually processed, the problem is to minimize degradation in quality caused by the action of bacterial and autolytic enzymes. It is universally recognized that expeditious handling of perishable food products is a prime requisite for maintaining quality. Limited information is available on the effect of length of ice storage of shrimp upon their quality during frozen storage *(7)*. No work has been reported of the effect upon quality of short time exposure of shrimp to air temperatures prior to washing and icing on trawlers. The present investigation was undertaken to determine the effect of delayed handling of shrimp aboard trawlers upon their quality during ice storage.

Shrimp are caught by towing a trawl net from the stern of the trawler. As the net scrapes over the mud of the bottom, shrimp and other marine life are disturbed and are funneled into the bag or tail of the net. After 1 to 3 hours of trawling, the net is hauled aboard and emptied. If further drags are necessary the net is again placed overboard. Since catches contain many species of sea life besides shrimp, considerable time is required to separate the shrimp from the remainder of the catch. They are then washed and the whole shrimp packed in alternate layers of ice, or they are headed and the headless shrimp washed and then packed between layers of ice. Depending upon the size of the catch, 1 to 3 hours or more may elapse between the time the net is emptied on the deck and the shrimp are finally iced.

MATERIALS AND METHODS

Shrimp used in these studies were caught in Barataria Bay adjacent to the Marine Laboratory of the Wildlife and Fisheries Commission. A 35 foot trawl net was used and after the net was emptied on deck, the boat returned to the Marine Laboratory where the shrimp were separated from trash fish. One-third of the shrimp were headed, washed with water from Barateria Bay, and a sample taken for bacterial count. The remainder of the headless shrimp were put in aluminum pans with covers and packed in ice. These operations required 20 minutes to complete from the time the net was emptied on the trawler. The remaining two-thirds of the whole shrimp were held without refrigeration in the laboratory where the temperature varied between 79–84° F. (25–29° C.). After 2 and 6 hours, samples were removed and handled in the same manner as the initial portion.

A second experiment was conducted in a similar manner with the following changes. The headless shrimp were washed and divided into two portions. One portion was soaked in water from Barateria Bay for 5 minutes, drained 2 minutes, placed in aluminum pans and packed in ice. The other portion was treated similarly except concentrations of 20 p.p.m. chlortetracycline (CTC) and 5000 p.p.m. isoascorbic acid were dissolved in water from Barataria Bay. Because the catch was small only a 2-hour holding period was used before heading, washing, dipping, putting in aluminum pans and storing in ice. The samples, well packed in ice, were transported to Louisiana State University laboratory at Baton Rouge in arctic hampers.

In the first experiment, samples were removed after 6 and 11 days ice storage, and in the second experiment after 7 and 15 days storage. During storage they were re-iced as required.

RESULTS AND DISCUSSION

It is recognized that high refrigeration temperatures or lack of refrigeration in the storage of perishable foods results in rapid loss of quality. This is especially true of shell fish in comparison with meat since the former do not go through an aging process. Tables 1 and 2 give results of the influence of air temperature holding of shrimp prior to ice storage upon pH, development of melanosis, bacterial count, or-

TABLE 1

Effect of air storage upon pH and organoleptic score and sweetness[1] during refrigerated storage

Air storage hours	pH			% Organoleptic score and sweetness		
	Days ice storage			Days ice storage		
	0	6	11	0	6	11
0	7.17	7.40	7.65	....	96 s[2]	82 s
2	7.17	7.52	7.85	....	85 s	59 ns
6	7.17	7.70	8.10	....	52 ns[3]	Spoiled

[1] Sweetness, although a part of the organoleptic score, is used here as a separate quality index as an indication of the degree of freshness of the samples.

[2] s = sweetness.

[3] ns = no sweetness.

TABLE 2

Effect of air storage upon bacterial plate count and development of black spot during refrigerated storage

Air storage hours	Bacterial plate count x 10^6/g.			% Severe black spot		
	Days ice storage			Days ice storage		
	0	6	11	0	6	11
0	.028	.395	.940	0	0	14
2	.031	.687	2.420	0	22	55
6	.057	2.100	70.000	0	76	98

ganoleptic score and sweetness. Although exposure to unfavorable temperature was of relatively short duration, it had a pronounced effect upon quality after 6 and 11 days ice storage as indicated by changes in the quality factors determined. The correlation between pH and organoleptic scores and sweetness confirms the previous suggestion from this laboratory *(1)* that pH can be used as a quite reliable index of quality. When the pH of shrimp reaches 7.7 the characteristic sweet flavor of fresh shrimp generally has completely disappeared.

It is rather surprising that those shrimp which remained at air temperature for 2 hours showed only a slight increase in bacterial count compared to the freshly caught shrimp, but after 6 and 11 days of ice storage the increase in bacteria were approximately 2 and 3 fold greater than the control, respectively.

The bacterial count of shrimp held for 6 hours at air temperature prior to ice storage was twice that of freshly caught shrimp. After 6 days in ice storage this increase was 5 fold, and after 11 days, 70 fold in comparison with the controls. These data demonstrate conclusively that small differences in the initial bacterial loads of shrimp result in large differences after ice storage, again pointing out the need for rapid pre-storage handling.

Similar results were obtained for melanin formation in shrimp ice-stored immediately after catching in comparison to shrimp held at room temperature prior to ice storage. Shrimp held for 2 hours prior to storage had 4 times as many severe black spots after 11 days of ice storage as the controls. Shrimp held for 6 hours before storage had 7 times as many severe black spots after 11 days of ice storage as the controls. Sigurdsson *(11)* in studying the effect of holding fresh herring at 80° F. (27° C.) showed that decomposition of protein, as measured by tyrosine value and amino nitrogen, occurs simultaneously with bacterial fermentation of carbohydrate. Holding at 32° F. (0° C.) or 29° F. (−2° C.) resuluted in a much slower rate of protein decomposition. Similarly holding shrimp at air temperature prior to ice storage may involve increased protein decomposition with the release of amino acids, including tyrosine, and the subsequent rapid conversion of the latter to melanin through the action of tyrosinase *(5)*.

As pointed out above, in commercial shrimp fishing several hours elapse between the time the trawl net is emptied and the shrimp are packed in ice. As noted in Table 2, melanosis becomes a severe problem when shrimp are allowed to remain at air temperatures for 2 hours or more prior to ice storage. Also, after 11 days' ice storage the bacterial load is sufficiently high to induce onset of spoilage. It was decided, therefore, to use a dip containing both a bacteriostatic agent, CTC at 20 p.p.m. and an anti-oxidant, isoascorbic acid, at 5000 p.p.m. The results obtained from this experiment are reported in Tables 3 and 4. The CTC-isoascorbic acid treatment had little effect in improving quality as indicated by pH or organoleptic scores. After 15 days' ice storage, the CTC isoascorbic acid treated shrimp had a brighter color and somewhat better flavor than the water dipped shrimp. The taste panel could detect no differences between control and chemical treated shrimp when they were held at air temperatures for two hours prior to storage for 15 days. The initial bacterial load of the headless shrimp was quite low and did not reach excessively high values through 15 days' ice storage. The bacteriostatic agent caused a small decrease in bacterial numbers which is in agreement with previous results demonstrating that CTC is not so effective when used on shrimp as it is on fish *(4, 6)*. The antioxidant, isoascorbic acid, at the concentration used, was more effective in preventing melanosis in shrimp which had

TABLE 3

Effect of air temperature storage and CTC-isoascorbic acid dip upon pH and organoleptic score and sweetness[1] during refrigerated storage

Air temperature storage hours	Treatment	pH			% Organoleptic score and sweetness		
		Days ice storage			Days ice storage		
		0	7	15	0	7	15
0	Water dip	6.96	7.42	7.69	....	93 s[2]	88 ss[3]
0	CTC-isoascorbic dip	....	7.49	7.77	....	96 s	90 ss
2	Water dip	6.97	7.43	7.71	....	96 s	77 ns[4]
2	CTC-isoascorbic dip	....	7.47	7.75	....	96 s	77 ns

[1] Sweetness, although a part of the organoleptic score, is used here as a separate quality index as an indication of the degree of "freshness" of the samples.

[2] s = sweetness.

[3] ss = slight sweetness.

[4] ns = no sweetness.

TABLE 4

Effect of air temperature storage and CTC-isoascorbic acid dip upon bacterial plate count and black spot development during refrigerated storage

Air temperature storage hours	Treatment	Bacterial count x 10^6/g.			% Severe black spot		
		Days ice storage			Days ice storage		
		0	7	15	0	7	15
0	Water dip	0.010	0.436	1.560	0	3.3	31
0	CTC-isoascorbic dip	....	0.389	1.270	0	0.0	24
2	Water dip	0.012	0.503	2.390	0	10.5	38
2	CTC-isoascorbic dip	....	0.451	1.840	0	0.0	41

TABLE 5

Effect of CTC-isoascorbic acid upon total black spot development

Air temperature storage hours	Treatment	% Total black spot		
		Days ice storage		
		0	7	15
0	Water dip	0	53	77
0	CTC-isoascorbic dip	0	0	47
2	Water dip	0	68	100
2	CTC-isoascorbic dip	0	33	68

not been held at air temperatures than those which stood two hours at air temperatures. This is illustrated in Table 5 which shows the total percentage of melanotic shrimp. Also, it was more effective during the early period of ice storage.

It has been observed that the black line, sand vein or intestinal tract remains attached to the shrimp head and is thus removed from the fleshy part of the tail if the shrimp are headed soon after they are landed. Allowing shrimp to remain one-half hour or longer before heading results in a very large percentage of the intestinal tracts remaining imbedded in the tail. Green *(9)* has shown that the sand vein removed aseptically from headless shrimp had a count of 7,000 bacteria per intestinal tract. The total count on headless shrimp from the same catch was 51,000 per gram. She also found that washing headless shrimp reduced the bacterial load to 7,400 per gram. It is evident that thorough washing removes a large quantity of bacteria present on the surface of headless shrimp and thus is an essential part of good processing. However, washing will not remove the bacteria in the sand vein if it remains in the flesh of the tail. This may explain the large increase in bacterial counts during ice storage when shrimp are exposed to air temperatures of 2 and 6 hours prior to icing. Beatty and Gibbons *(2)*, measuring chemical products of bacterial action, found in cod only slight bacterial activity in a few days at 64.4° F. (18° C.) in the back muscle, but considerable activity in the peritoneum.

A high percentage of shrimp are dead by the time the trawl net is emptied on deck, and those which have survived die within a few minutes. While no figures are available, general observations indicate that shrimp do not remain in rigor mortis as long as fish. Cutting *(3)* has pointed out that invasion of the flesh by bacteria cannot assume significant proportions until rigor has passed. He also studied the effect of storing gutted and ungutted fish in ice and in air at deck temperatures 52–61° F. (11–16° C.) upon the duration of rigor mortis. Chilling in ice did not affect the rate of onset of rigor mortis, compared with holding at air temperature, but it delayed resolution by about 10 hours. This would also help explain the retention of quality for longer periods during ice storage of shrimp when the time of holding at air temperatures is decreased. Reay and Shewan *(10)* report that herring iced immediately after catching and kept in ice thereafter remain "fresh" from 23 to 40 hours (av. 32 hours). Fish iced only after landing, usually from 6 to 12 hours after catching, were found to have passed through the "freshness" state before, or to pass through it very soon after, ice is applied. Similarly, freshly caught shrimp have a characteristic flavor which is somewhat sweet and the authors *(8)* point out that shrimp which were processed and stored in ice almost immediately after being caught lost most of their fresh flavor after 3 days in storage.

SUMMARY AND CONCLUSIONS

Two experiments are described which were designed to determine the effects of delayed handling upon subsequent ice storage quality of shrimp. In one experiment, bacteriostatic and antioxidant agents were used in attempts to retain "fresh" quality shrimp for longer periods than those which ordinarily prevail during ice storage.

Holding fresh shrimp for two hours at air temperatures 79–84° F. (26–29° C.) before icing resulted in a 2 fold increase in bacteria after 6 days of ice storage in comparison with controls iced immediately after catching. After 11 days of ice storage the bacterial count had increased 3 fold in comparison with the controls. When shrimp were held 6 hours before icing the increase over the controls was 5 fold after 6 days of ice storage and 70 fold after 11 days of ice storage. Results obtained by organoleptic analysis of quality and the pH in general paralleled bacteriological quality of these samples.

Keeping shrimp at air temperatures prior to icing also resulted in increased melanosis. Shrimp held for 2 hours prior to storage had 4 times as many severe black spots after 11 days ice storage, as the controls, while those held for 6 hours before icing had a 7 fold increase in severe black spots after 11 days ice storage.

The mixture of CTC and isoascorbic acid was slightly effective in retarding bacterial growth and decreased the development of melanosis provided shrimp were processed shortly after catching. These agents were much less effective when used upon shrimp which had been held 2 hours at air temperature.

Evidence presented stresses the need for rapid processing of freshly caught shrimp. For superior quality retention during ice storage, shrimp should be removed from trash fish and headed within an hour or as soon as possible after being caught. This treatments should result in removal of sand veins, high in bacteria, and may retard melanosis appreciably during ice storage. Adequate washing after heading should also contribute a beneficial effect on the ice storage life of the product.

Acknowledgment

The authors wish to thank Mr. James M. McConnell and Dr. Lyle St. Amant for placing at our disposal laboratory facilities of the Louisiana Wildlife and Fisheries Commission and the American Cyanamid Company for financial assistance.

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Factors Affecting Quality of Prepackaged Meat[a]

IV. Microbiological Studies. B. Effect of Package Characteristics and of Atmospheric Pressure in Package upon Bacterial Flora of Meat[b,c]

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THE SPECIFIC OBJECTIVES of the microbiological phase of this investigation were to ascertain; (a) factors which influence bacterial growth in prepackaged meat, (b) kinds of microorganisms which grow at the storage temperatures used, and (c) the relationship between bacterial growth and the color changes observed in prepackaged meats.

Numerous reports have appeared in the literature on the numbers and types of bacteria present on fresh meats. General reviews are given by Emprey and Scott *(4)*, Jensen, *(5)* and Ayres *(1)*. Many investigators who have determined the bacterial flora of fresh meats, emphasized those microorganisms associated with recognizable deleterious effects, such as sliming *(2)* and souring *(8, 10)*. Part IV will cover only the factors which influence the growth in prepackaged meat of the microorganisms which grow at the storage temperatures used.

PROCEDURE

The meat was prepared according to the procedure outlined in the introductory article of this series. Precautions were taken to ensure that the equipment used was sanitary and sample preparation was accomplished quickly to minimize the initial microbial load.

Packaging and storage variables. The following packaging materials were used in this portion of the investigation:

Package 2	control enameled can, 307–306 or 307–211
Package 4a	vinylidene copolymer
Package 6	MSAT86 cellophane—coated both sides
Package 6a	MSAT80 cellophane—coated side inside
Package 6d	MSAT80 cellophane—coated side outside
Package 8	Cellulose acetate
Package 10	Polyethylene
Package 15	Cellophane-pliofilm laminate
Package 17	Cellulose acetate-pliofilm laminate

After packaging, the samples were stored in a refrigerated cabinet. At specified intervals the samples were removed for examination and bacteriological analysis.

No less than 3 packaged samples each of lean and fat from each packaging material were analyzed at a removal time. For example, if there were 3 package types and 5 removal times, a total of at least 90 samples were packaged, of which 45 were lean and 45 fat.

In the early phase of the investigation the storage temperature was between 34° and 38° F. and samples examinations were made at either 0, 7, 14, 21, 28 or 0, 6, 12, 18, 29 days of storage. In later experiments starting with Run R, the storage temperatures were either 34° to 38° F. or 40° to 44° F. and removal days were on 0, 2, 4, 7, 10, and 14 days after packaging.

The following runs were designed to determine specific facts about bacterial growth in prepackaged meats:

(1) Run P—to ascertain whether or not the inhibition of bacterial growth observed in meat packaged in cellophane-pliofilm laminate in Runs H to O was apparent before the seventh day of storage.

(2) Run R—to establish the role of vacuum sealed cellophane-pliofilm laminate in the inhibition of bacterial growth in prepackaged meat.

(3) Runs P and S—to establish the effect of initial bacteria count on the rates of growth in packaged meats. Meat was inoculated in these runs. Results on this phase will be published later.

Examination. Meat samples were removed on examination day in numbers which could be analyzed within one hour. Three or 4 removals were made on an examination day. Precautions were taken to keep the samples chilled and to remove them from the packages aseptically.

Ten grams of meat were removed from each package with a sterile spoon. The sample was placed in a tared liter flask containing 90 ml. of physiological saline. The flask plus sample was then reweighed. After shaking, serial dilutions were made from the initial suspension. After shaking the dilution bottles, plates were poured. The plating dilutions used were dependent upon how long the samples had been stored prior to removal.

Media. A number of selective media were used to detect population changes, but were later discarded. The following media gave the most promising results and were therefore used until after the classification studies were made; veal infusion, Jensen's lard, Turner's lard with Nile Blue Sulfate, and gelatin-peptone agar medium. Only veal infusion agar was used after the classification and statistical studies were completed.

Incubation. Plates were incubated for 4 days at 28° C. Bacterial colonies were counted with the aid of a Quebec colony counter. A record was kept of the total bacteria count, the components of the count, the number of oxidase and lipase formers and gelatin liquefiers. Gelatin liquefiers were counted by flooding the media with 1% mercuric chloride and recording the number of colonies showing zones of liquefaction. Oxidase positive colonies were determined by flooding Jensen's agar

[a] A report of work conducted by contract with the Bureau of Animal Industry, U. S. Department of Agriculture, with funds provided under the Research and Marketing Act. The investigation covers (1) physical and organoleptic studies, (2) color studies, (3) chemical studies, and (4) microbiological studies.

[b] A paper of the Journal Series, N. J. Agricultural Experiment Station, Rutgers University, the State University of New Jersey, Departments of Food Technology and Animal Husbandry, New Brunswick, N. J.

[c] Data from Ph.D. thesis of Frank E. Halleck.

plates with 0.4 per cent tetramethyl-p-phenylenediamine dihydrochloride and recording the number of colonies that reduce the colorless dye to purple. Lipolytic counts were obtained from the plates of the Nile Blue sulfate lard agar. Initial counts on the unpackaged ground meat on the day of packaging were obtained similarly to the counts of the packaged meat.

Basis of counting. Microbial counts were calculated as the number of microorganisms per gram of sample. An arithmetic mean was taken of the replicate samples. The standard deviation and the standard error of the means were calculated. To ascertain the statistical difference in the counts obtained from the meats subjected to different packaging conditions, the standard error of the difference between the mean counts (the "t" value) at each examination was calculated. Significant "t" values indicated a real mathematical difference between the counts. The linear relationships between the total bacteria counts and other counts were obtained using a correlation coefficient calculation.[d]

Classification[e]

Representative colonies were picked off the plates for stock cultures and classification. Records were kept of the meat sample code number, the dilution at which the culture was isolated, and the number of colonies of each group of similar bacterial colonies on the plate. With this information, the number of bacterial cells of each type, per gram of meat, at each examination time was established. One hundred and four cultures were isolated from the ground lamb and 120 from the ground beef.

The stock cultures were classified according to the procedures outlined in Bergey's *Manual (3)* and the *Manual of Methods for Pure Culture Study of Bacteria (6)*. Lipase and oxidase production tests were added to determine whether or not the isolates were capable of attacking fats either hydrolytically or oxidatively or both.

An investigation was made to determine the types of bacteria which are present and grow aerobically on fresh ground lean and fat lamb and beef during a 29 day storage period at 34° to 38° F. The classification studies were made to test 3 hypotheses: (1) that the same genera of bacteria persist throughout the storage period, (2) that the colonial morphology of each type of bacterium is sufficiently distinct from that of another type of bacterium to make possible the identification of its genus by visual observation, and (3) that the use of various selective media would be successful in detecting bacterial population changes during storage.

Achromobacter-Pseudomonas-type bacterium inoculation[f]

In two runs the meat was inoculated with cultures of *Achromobacter-pseudomonas* type bacterium. In Run P, in which ground lamb was the test meat, the following method was used. A starter culture of *Achromobacter-pseudomonas* type sp. designated as culture No. 61, was grown in 50 ml. of Difco nutrient broth for 24 hours at 28° C. One ml. portions of the starter culture were used as the inocula for 10 liters of Difco nutrient broth distributed among eight 1-liter flasks. The inoculated flasks were incubated on the shaker for 24 hours at room temperature and the cells were harvested by centrifugation. The packaged cells were held for 4 days at 34° F. The inoculum was diluted to 500 ml. and filtered. The inoculum was mixed with 10 lbs. of ground pork in a Hobart Mixer for 5 minutes. As a control, 500 ml. of distilled water was added to 10 lb. of the uninoculated meat.

In Run S, the meat was packaged in the can, MSAT80 cellophane, coated side in, and cellophane-pliofilm laminate for examination at 0, 2, 4, 7, 10 and 14 days.

[d] Brownlee, K. A. 1949. *Industrial Experimentation.* Chemical Publishing Co., Inc., Brooklyn, N. Y., 3rd ed., 194 pp.

[e] Results of the classification study will be published later.

[f] Results of the inoculation study will be published later.

Antibiotics[g]

To each of twelve 1-later flasks was added 225 g. of mixed lean and fat ground pork. To each flask was then added 10 ml. of water solution of an antibiotic. The concentration of antibiotic in the meat was as follows:

Neomycin I	95.5 γ/g.	Streptomycin I	403 γ/g.
Neomycin II	175 γ/g.	Streptomycin II	108 γ/g.
Bacitracin I	105 γ/g.	Penicillin I	161 γ/g.
Bacitracin II	122 γ/g.	Penicillin II	138 γ/g.
Combination I		Combination II	
(Penicillin	83.5 γ/g.)	(Penicillin	3.3 γ/g.)
(Bacitracin	22.5 γ/g.)	(Bacitracin	119.3 γ/g.)

Flasks in which the antibiotic solutions had been prepared were rinsed twice with 10 ml. of distilled water and the rinsings added to the meat. Antibiotics were mixed into the meat thoroughly.

To two flasks to be used as controls were added 30 ml. of distilled water. The flasks were restoppered and stored at 40° to 44° F. for examination at 0, 2, 4, and 7 days. For examination 10 g. duplicate samples were removed from the flask and each was placed in 90 ml. of sterile saline diluent. The standard plating-dilution technique was used.

Antioxidants[g]

Two antioxidants were added to the meat, ascorbic acid and nordihydroguaiaretic acid (NDGA). The ascorbic acid was made into a solution and added to the meat so that the final concentration was 0.1 per cent in the meat. Water was added to control sample. The NDGA was added in the dry state so that the final concentration in the meat was 0.05 per cent. The antioxidants were distributed throughout the meat by mixing with a Hobart Mixer for 5 minutes.

RESULTS

The most pertinent data are presented in Figures 1 through 5 and in Tables 1 through 4. The graphs

[g] Results of the studies of the effects of antibiotics and antioxidants upon bacterial flora will be published later.

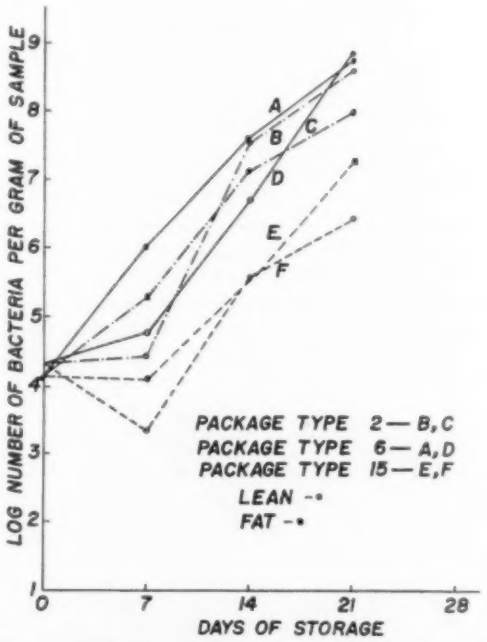

Figure 1. Mean total bacteria counts in lean and fat ground beef in package types 2, 6, 15 stored at 34–38° F. Run H.

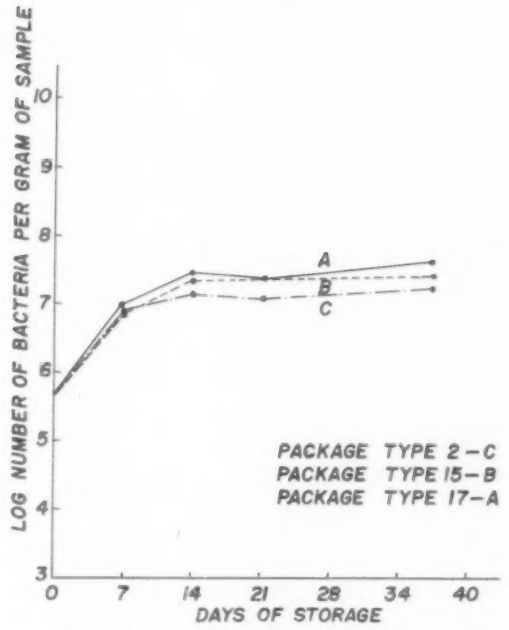

Figure 2. Mean total bacteria counts in fat ground pork in package types 2, 15 and 17 stored at 34–38° F. Run M.

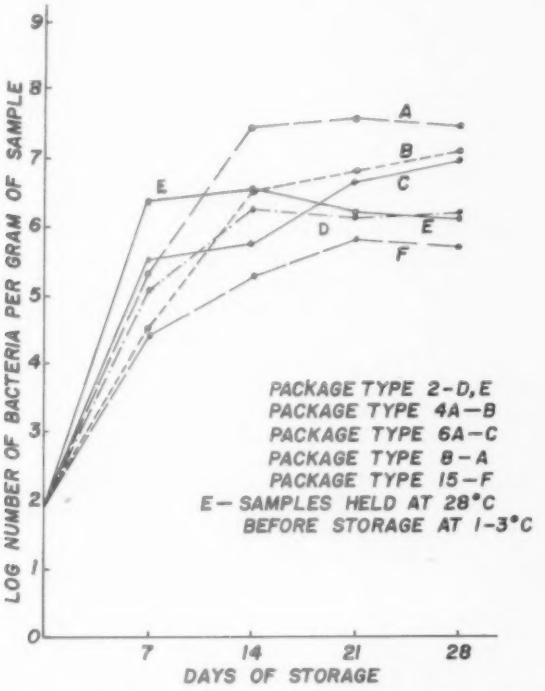

Figure 4. Mean total bacteria counts in fat ground beef in package types 2, 4a, 6a, 8 and 15 stored at 34–38° F. Run O.

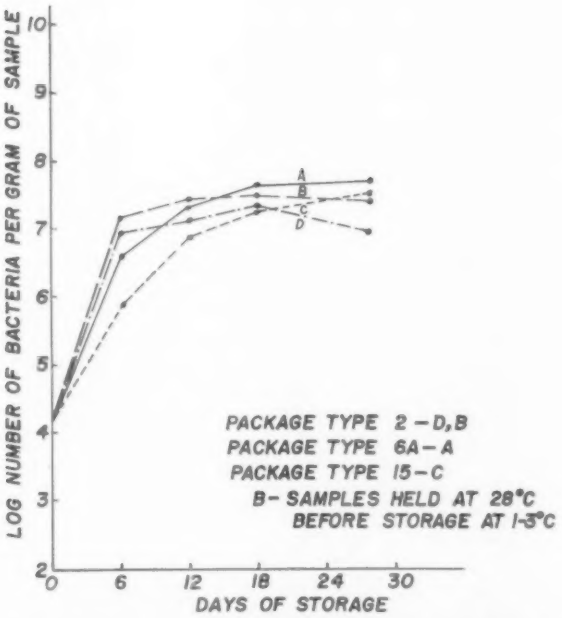

Figure 3. Mean total bacteria counts in fat ground lamb in package types 2, 6a and 15 stored at 34–38° F. Run N.

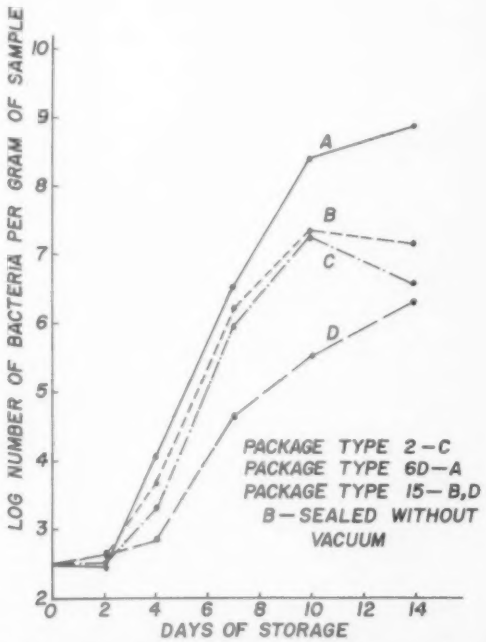

Figure 5. Mean total bacteria counts in fat ground lamb in package types 2, 6d, and 15 stored at 40–44° F. Run R.

TABLE 1

Significance of difference between means of total bacteria counts from meat under different packaging conditions. Run H

	Calculated "t" values [1]		
	Package type	6	15
Lean			
7 Days	2	0.648	1.37
	6		1.25
14 Days	2	3.47	4.14
	6		2.05
21 Days	2	2.68	8.86
	6		6.90
Fat			
7 Days	2		3.38
	6	1.98	6.90
14 Days	2		10.05
	6	2.66	4.19
21 Days	2		2.30
	6	7.09	10.1

[1] Johnson, P. O. *Statistical Methods* (1949). Calculated "t" values should exceed 2.02 to have significance.

TABLE 2

Significance of difference between mean total bacteria counts. Run N

	Calculated "t" values [1]			
	Package type	6a	15	2 –(20 hr.)[2]
6 Days	2	0.267	54.0	1.67
	6a		1.75	3.05
	15			4.43
12 Days	2	1.89	3.10	8.28
	6a		3.83	2.18
	15			12.9
18 Days	2	1.46	0.595	0.750
	6a		2.02	1.04
	15			1.03
29 Days	2	3.80	4.14	5.43
	6a		1.48	2.39
	15			1.48

[1] Johnson, P. O. *Statistical Methods* (1949). Calculated "t" values should exceed 1.81 to have significance.
[2] Held at room temperature for 20 hours before being placed in storage.

TABLE 3

Significance of difference between total bacteria counts. Run O

	Calculated "t" values [1]					
	Package type	4a	6a	8	15	2 –(20 hr.)[2]
7 Days	2	1.60	1.76	0.720	1.66	36.3
	4a		3.17	1.96	0.264	15.0
	6a			1.11	3.22	1.96
	8				1.96	12.1
	15					
14 Days	2	1.38	3.15	6.21	7.63	2.21
	4a		2.65	5.76	10.1	1.43
	6a			6.51	0.919	3.84
	8				6.62	5.81
	15					4.98
21 Days	2	3.67	2.88	4.64	2.41	0.674
	4a		1.02	3.93	4.20	3.55
	6a			4.19	3.51	2.73
	8				4.73	4.61
	15					3.25
28 Days	2	5.63	2.25	2.93	2.23	0.049
	4a		0.832	1.44	6.29	5.65
	6a			1.95	2.57	2.25
	8				3.01	2.93
	15					2.46

[1] Johnson, P. O. *Statistical Methods* (1949). Calculated "t" values should exceed 2.02 to have significance.
[2] Held at room temperature for 20 hours before being placed in storage.

TABLE 4

Significance of difference between total bacteria counts. Run R

	Calculated "t" values [1]			
	Package type	6d	15[2]	15(n.v.)[3]
2 Days	2	0.660	3.03	2.95
	6d		2.95	1.00
	15			0.039
4 Days	2	10.4	1.35	2.17
	6d		27.9	7.41
	15			4.33
7 Days	2	4.70	17.0	1.22
	6d		9.68	3.04
	15			3.36
10 Days	2	6.36	2.36	6.03
	6d		7.01	6.23
	15			2.34
14 Days	2	4.85	1.62	3.00
	6d		4.85	11.5
	15			3.50

[1] Johnson, P. O. *Statistical Methods* (1949). Calculated "t" values should exceed 1.81 to have significance.
[2] Films sealed under vacuum of 27 inches.
[3] Films sealed at atmospheric pressure.

show how bacterial growth was affected by package types.

Packaging conditions. Can (Package 2). The can, which was used as a control, permitted bacterial growth to a population maximum of approximately 1 to 10 million cells per gram of meat, irrespective of the storage temperature and the initial bacteria count. Waste products from the metabolism of the organisms and the vacuum in the can may have controlled the magnitude of the growth.

Data in Tables 1 to 4, inclusive, indicated that the mean bacteria counts in can-packaged meat were significantly different from those in meat from MSAT86 cellophane (package 6, Run R), MSAT80 cellophane (packages 6a and 6d, Runs N, O, R) and cellulose acetate (package 8, Run O), during most of the 14 to 28 day storage period at 34–38° F. or 40–44° F.[b]

When can-packaged meat was held at 82.4° F. for 20 hours prior to storage at 34–38° F. a high rate of growth occurred. All counts made (starting on the 7th day) during storage at 34–38° F. showed essentially no changes; therefore, it was assumed that further increase in viable cell count did not take place during a storage at 34–38° F., since a population maximum had apparently been reached during the first 20 hours (Figures 3 and 4)[1] and (Tables 1 and 3).[1] Maximum bacteria counts on samples stored immediately after packaging at 34–38° F. were statistically equivalent to those on samples held at 82.4° F. for 20 hours prior to storage. These data support evidence that the can permits only limited bacterial growth. The magnitude of bacterial population maxima in can-packaged meat depended upon the effects exerted by the can, not upon the initial bac-

[b] Additional comparisons, some of them involving polyethylene (package 10) will be published later.
[1] Additional comparisons, some of them involving polyethylene (package 10) will be published later.

teria count. The addition of an *Achromobacter-pseudomonas* type inoculum to meat packaged in cans increased the initial bacteria count of the meat in Runs P and S. Data to be published later indicate that in the late part of the storage period, the bacteria counts of the non-inoculated meat are equivalent to the counts of the inoculated meat. The magnitude of the growth was limited also in this case.

Permeable packaging materials. Single ply non-laminated films, such as cellophane, polyethylene, and cellulose acetate permitted bacterial growth at approximately the same rate as in unpackaged meat, therefore, their influence on bacterial growth was not appreciable.

MSAT86 cellophane (Package 6). The data of Run H are shown in Figure 1 and Table 1. The mean bacteria counts were significantly higher than those found in the can (package 2) throughout the 21 day storage period at 34–38° F. Mold growth and dehydration may have limited the rate of growth during the latter part of the storage period.

MSAT80 cellophane (Packages 6a and 6d). The results of Runs O, R, and S, shown in Figures 4 and 5, indicated that the mean bacteria counts of meat packaged in this material was consistently higher than meat packaged in the can (package 2) and in the non-permeable films.[j] The leveling off of the bacteria counts in packages 6a and 6d is presumed to have been due to the presence of strains of *Mucor* and *Penicillium* and the progressive dehydration of the meat. Optimal bacterial growth in this packaging material occurred during the first two weeks of storage.

In Run S[j] bacterial growth in meat inoculated with *Achromobacter-pseudomonas* type bacterium and packaged in MSAT80 cellophane coated side out, was confined to the first 4 days of storage at 40–44° F. At this time (4 days) the mean bacteria counts of inoculated meat were significantly higher than those in inoculated meat packaged in other materials. After four days, bacterial growth did not occur, which indicated that the maximum had been reached. The population maxima of both the inoculated and uninoculated meat were of the same magnitude.

Polyethylene (Package 10). Mean bacteria counts were significantly higher in meats packaged in polyethylene than those found with packages 2 and 15.[j] The gas permeability of polyethylene probably influenced the high growth rate of the bacteria since no dehydration of the meat was observed and the lag phase appeared to be shorter than usual.

Cellulose acetate (Package 8). In Run O (Table 3), the mean bacteria counts were significantly higher in film 8 than in the can (package 2) or in film 6a. Bacterial growth was confined to the first two weeks of storage at 34–38° F. During the last two weeks a heavy growth of a strain of *Mucor* may have limited bacterial growth. Marked dehydration also occurred. Bacterial growth in this film resembled growth in unpackaged meats.[k]

[j] Additional graphic comparisons will be published in a subsequent article.

[k] Data will be presented in a graph to be published later.

Non-permeable packaging materials. Some influence was exerted on the rate of bacterial growth in meat packaged in vinylidene copolymer (4a), cellulose acetate-pliofilm laminate (17), and cellophane-pliofilm laminate (15).

Vinylidene copolymer (Package 4a). In Run O, bacterial growth in package 4a was similar to that in can-packaged meat during the first two weeks of storage at 34–38° F. After that time the growth was similar to that in the highly permeable films like MSAT80 (6a). The population maximum in package 4a was about the same as that found with package 6a. Loss of vacuum may have caused the high growth rate during the latter part of the storage period.

Cellulose acetate-pliofilm laminate (Package 17). At 34–38° F. bacterial growth, in Run M, of meat packaged in film 17 was similar during the first two weeks of storage to that of the can-packaged meat (Figure 2). The magnitude of the population maximum also was equivalent to that of the can. Gas retention of the package probably inhibited bacterial growth since the growth rate was much lower than that of most other films.

Cellophane-pliofilm laminate (Package 15). A profound effect on the rate of growth of bacteria on meat was observed with this packaging material, as shown in Figures 1–5, depicting data from Runs H, M, N, O, and R. The rate of bacterial growth in fim 15 was much lower than that found in other packaging materials. In Run R, it was noted that vacuum sealing may have contributed to this effect (Figure 5). Bacterial growth in the meat sealed without vacuum in film 15 was similar to that of meat in package 2. With vacuum the bacterial growth rate was much lower in film 15 than in the can or in film 15 without vacuum. This inhibition was manifested in a lengthened lag period.

SUMMARY

Storage temperature, storage time, packaging material, and the initial bacteria counts had effects on bacterial growth in packaged meats. The primary effect of packaging materials on bacterial growth showed significant correlation with the gas-water vapor permeability of the materials.

Permeable films (cellophane, cellulose acetate, and polyethylene) permitted growth at optimal rates until dehydration or mold growth interfered. Growth rates in the permeable films was controlled by storage temperature only after the completion of the lag growth phase. Population maxima were attained at the same time that dehydration and mold growth were prevalent.

Non-permeable packaging materials (the can, cellulose acetate-pliofilm laminate, and cellophane-pliofilm laminate) influenced bacterial growth by the atmosphere produced within the container. Growth in these materials was marked by a longer lag phase than in the permeable films. Bacterial growth seemed to be specific for the packaging material. Cellophane-pliofilm laminate inhibited bacterial growth more than other packaging materials studied. Vacuum in this

package was a contributing factor in the inhibition of growth.

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Time-Temperature Tolerance of Frozen Foods

XIII. Effect of Regularly Fluctuating Temperatures in Retail Packages of Frozen Strawberries and Raspberries

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(Manuscript received October 14, 1957)

Effects of times and temperatures on quality changes in various frozen fruits have been presented *(1, 2, 3, 4, 5, 6)*. Although brief summaries on the effects of regularly fluctuating temperatures have been included in each paper, a more detailed discussion of the subject with experimental data is deemed desirable. Results from carefully controlled experiments indicate that fluctuation *per se* is not an important factor in quality changes in commercially packed frozen strawberries and raspberries.

MATERIALS AND METHODS

All fruit used was obtained from commercial freezing plants during the seasons 1950 to 1954. Detailed information on packing and freezing of samples is given in the papers on strawberries *(3)* and raspberries *(4)*. Samples of each lot were placed under various sine-wave fluctuating temperature schedules and compared with other samples from the same lot held at $-20° \pm 1°$ F. and other steady temperatures representing the mean, maximum, and minimum of the fluctuating cycles. Although environmental rather than product temperature was controlled, the small packages were individually exposed to air moving at approximately 50 feet per minute, so that the center temperature of the packages followed the air temperature reasonably well.

Some of the fluctuating cycles were varied with respect to both frequency and amplitude. The product temperatures obtained in the various cycles are shown in Figure 1. Details of the refrigeration facilities and how the regular temperature variations were obtained are discussed by Lowe *et al. (8)*.

Organoleptic evaluation. Flavor evaluation of these samples was carried out by triangle test with 10 to 15 trained judges. Each comparison was conducted twice, giving a total of 20 to 30 judgments. Comparisons were made between samples subjected to the fluctuating cycle and $-20°$ F. controls, between cycle and mean steady temperature, and occasionally between

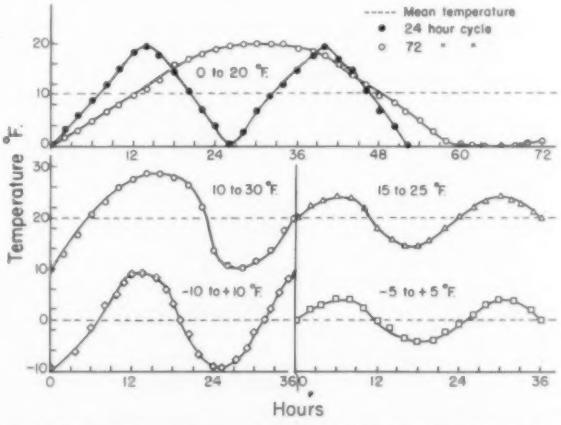

Figure 1. Product temperatures obtained during fluctuating cycles of 0° to 20°, 10° to 30°, 15° to 25°, −10° to +10°, and −5° to +5° F.

* Western Utilization Research and Development Division, Agricultural Research Service, U. S. Department of Agriculture.

cycle and maximum steady temperature. All samples were thawed for 2 hours in circulating air at 70° F. prior to tasting.

Objective measurements. Reduced ascorbic acid was determined on the thawed berries by the method of Loeffler and Ponting *(7)*. Each result represents the average of 4 packages.

Color in strawberries was determined by Hunter Color Difference Meter as described in the paper on strawberries *(3)*. Color changes in raspberries were determined by the method previously described *(6)*.

Drained weights were determined by thawing the packages in circulating air at 70° F. for 2 hours and draining on an 8-mesh screen for 2 minutes.

Soluble solids were determined by refractometer and expressed as per cent sucrose.

RESULTS

As shown in Figures 2 to 7 the initial rates (determined from linear portion of curves), of ascorbic acid oxidation and color changes for steady temperatures within the range of a given fluctuating cycle vary exponentially with temperature. Using Q_{θ}[b] values calculated from the straight lines drawn through the steady temperature data, the effective temperature for each of the sine wave fluctuating cycles was calculated according to the graphs and formulas given by Schwimmer, Ingraham, and Hughes *(10)*. The rates of ascorbic acid oxidation and color change obtained for each of the cycles were plotted at the calculated effective temperature in the appropriate temperature ranges. If fluctuation *per se* causes greater damage than would be expected on the basis of a calculated effective steady temperature, the rate values for the various fluctuating cycles should be consistently higher than the predicted values.

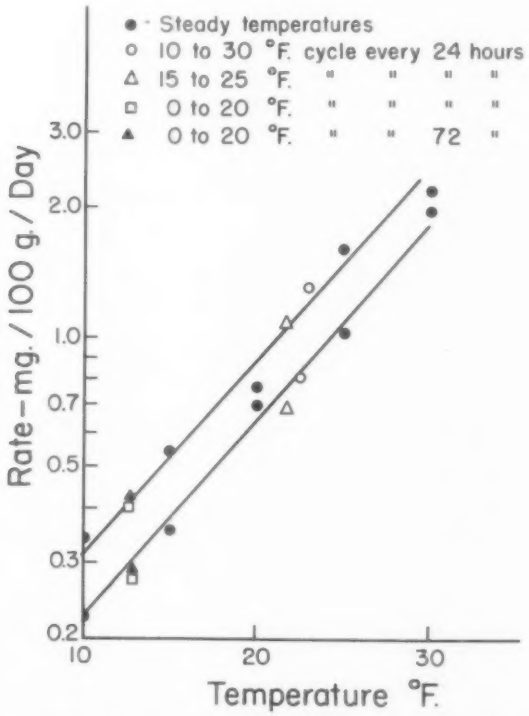

Figure 2. Relation between initial rate of ascorbic acid loss and temperature in the 10° to 30° F. range for two different lots of frozen strawberries. Points for fluctuating cycles are plotted at the calculated effective temperature.

[b] Q_{θ} = ratio of the reaction rate at $(T_{\theta} + A)$ to that at T_{θ}. T_{θ} = mean temperature, A = amplitude (half the range between maximum and minimum temperature).

Ascorbic acid. Examination of Figure 2 shows that in 2 lots of strawberries from different areas, the rate of ascorbic acid oxidation for fluctuating cycles in the range of 10° to 30° F. 15° to 25° F., and 0° to 20° F. were not consistently higher than the predicted values but fell both above and below the lines drawn through the steady temperature data. Therefore, it does not appear that fluctuation *per se* causes more ascorbic acid loss than would be expected at an equivalent steady temperature. Figure 3 indicates that this is also true for cycles from −10° to +10° and −5° to +5° F.

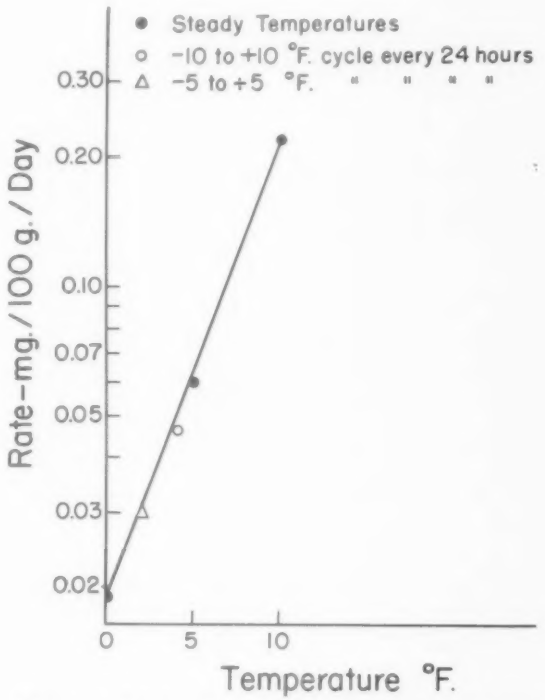

Figure 3. Relation between initial rate of ascorbic acid loss in frozen strawberries and temperature in the 0° to +10° F. range. Points for fluctuating cycles are plotted at the calculated effective temperature.

According to Schwimmer, Ingraham, and Hughes *(10)* the effective temperature increases with increasing amplitude and Q_{θ} values but is unaffected by changes in frequency as long as the amplitude is constant. The experimental data agree fairly well with this theory (Figures 2 and 4). Rates for the 10° to 30° and −10° to +10° F. cycles were higher than the 15° to 25° and −5° to +5° F. cycles (same mean temperatures but different amplitudes). When the amplitude was kept constant at 0° to 20° F. and the frequency changed from 1 to 3 cycles every 72 hours, no essential difference was observed in ascorbic acid loss due to the differing frequencies. This observation is rather significant, because if fluctuation produced effects other than those due to temperature, it would be expected that a higher frequency would cause more loss than a lower one.

Figure 5 shows the rates of ascorbic acid loss in raspberries for sine wave cycles of 10° to 30°, 15° to 25°, 0° to 20° F. and steady temperatures in this range. As for strawberries the rates obtained from the cycles were very close to the expected values on the basis of a calculated effective temperature. Again it will be noted that the rates obtained from steady temperatures deviate from a straight line about as much as, or more than, those obtained from the cycles.

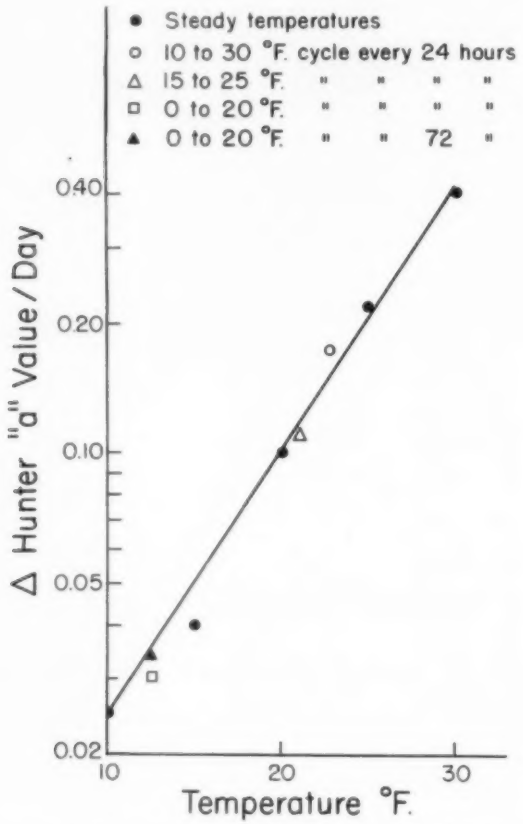

Figure 4. Relation between change in Hunter "a" value in frozen strawberries and temperature in the 10° to 30° F. range. Points for fluctuating cycles are plotted at the calculated effective temperature.

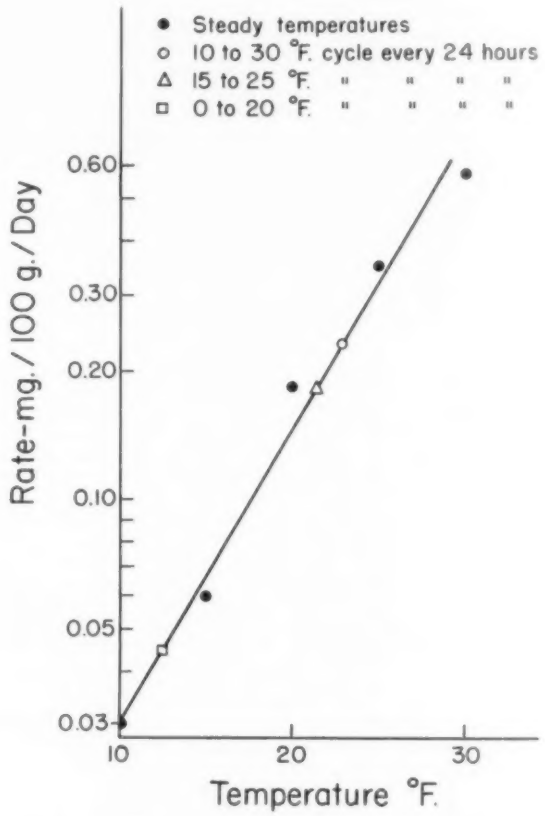

Figure 5. Relation between initial rate of ascorbic acid loss in frozen raspberries and temperature in the 10° to 30° F. range. Points for fluctuating cycles are plotted at the calculated effective temperature.

Color. The relation between various fluctuating cycles and steady temperatures is shown in Figures 4, 6, and 7. As for ascorbic acid oxidation, color changes in both raspberries and strawberries occurring as a result of sine wave fluctuating cycles can be expressed in terms of equivalent steady temperatures. Again, deviations from this line are no greater for the cycles than for steady temperatures, thus indicating that within the variation of materials and procedure sine wave fluctuations do not demonstrate any unexpected effects with regard to color changes in both raspberries and strawberries. Figure 7 shows that the Q_{10} value from 0° to 10° F. for change in color ratio units is much greater than in the 10° to 30° F. range (Figure 6). The −10° to + 10° cycle represents an effective temperature of +6°F. above the mean (0° F.), whereas the 10° to 30° F. cycle represents an effective temperature of only 4° F. above the mean (+20° F.).

Since the Q_{10} value of the lower cycle is over 10 times greater than that of the higher cycle, it is apparent that fluctuations of equal amplitude will cause greater differences from the mean temperature in the −10° to + 10° F. range than in the 10° to 30° F. range.

Drained weight and soluble solids. Since soluble solids and drained weights did not change appreciably at steady temperatures from 0° to 20° F., it was impossible to calculate effective temperatures for fluctuating cycles covering this range. Soluble solids of the fruit increased gradually in the 15° to 25° F. cycle and rather rapidly in the 10° to 30° F. cycle. This would be expected on the basis of higher amplitude and thawing temperatures in the 10° to 30° F. cycle.

Soluble solids equilibrium in raspberries was attained in 8 days at 30° F. and in 24 days at the 10° to 30° F. cycle. At 25° F., equilibrium was not attained in a period of 2 months. No significant differences could be demonstrated in the drained weights of samples held at the fluctuating cycles and mean steady temperatures. This might be due to the extensive variations in fruit-to-liquid packing media, but since there is little or no difference in drained weights during storage at temperatures of 0° to 30° F. it is unlikely that fluctuation significantly affects this measurement.

Flavor evaluation. As shown in Table 1 comparison of strawberry samples held at various fluctuating cycles with those held at the mean steady temperatures showed no significant flavor

TABLE 1

Flavor comparisons between strawberries held at sine wave fluctuating temperatures and steady temperatures

Samples compared	Percentages of correct answers in triangle tests							
	Days of storage							
	6	13	20	25	60	120	270	365
− 5° to + 5° F. vs. 0° F.	....	....	....	....	40	35	28	32
−10° to + 10° F. vs. 0° F.	....	....	....	....	28	38	46	58[1]
−10° to + 10° F. vs. + 10° F.	....	....	....	....	25	25	35	42
0° to + 20° F. vs. + 10° F.	....	25	....	41	35	32	....	....
15° to 25° F. vs. + 20° F.	33	45	36	32	....	....	....	....
10° to 30° F. vs. + 20° F.	32	32	33	32	....	....	....	....

[1] Significant at the 1% level.

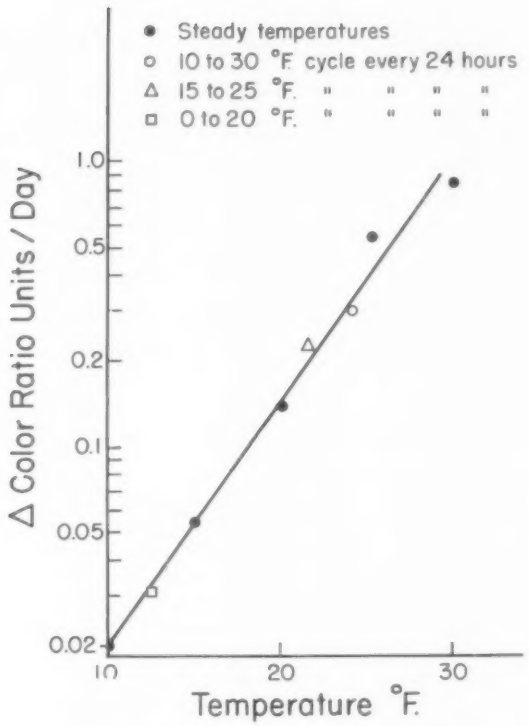

Figure 6. Relation between change in color ratio units in frozen raspberries and temperature in the 10° to 30° F. range. Points for fluctuating cycles are plotted at the calculated effective temperature.

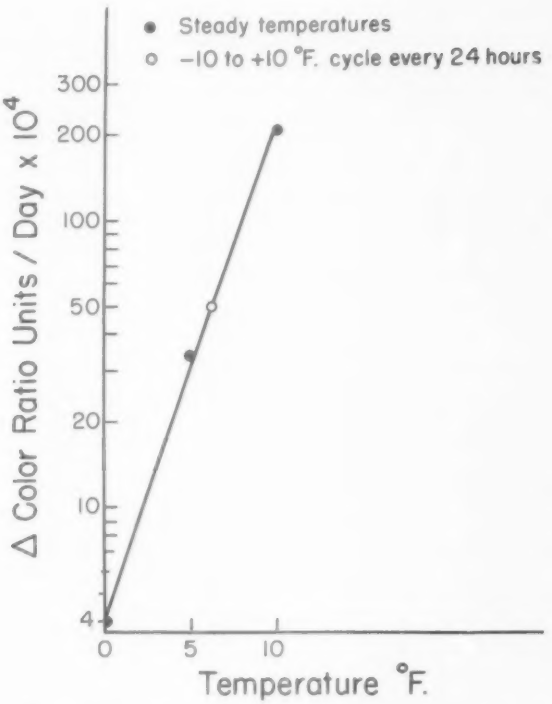

Figure 7. Relation between change in color ratio units in frozen raspberries and temperature in the 0° to 10° F. range. Points for fluctuating cycles are plotted at the calculated effective temperature.

differences up to one year of storage. The only exception was found in the comparison of samples fluctuated from −10° to +10° F. for one year with those held steadily at the mean (0° F.) for the same period; flavor change was significantly greater in the former. In fact there was no significant difference in flavor between these fluctuated samples and others held steadily at 10° F. for one year. The finding is consistent with a very high temperature coefficient of flavor change in this temperature region and a correspondingly high effective temperature.

Comparison of samples held at fluctuating temperatures with −20° F. controls gave results which were very similar to those obtained by comparing controls with samples held at the mean temperature.

Since ascorbic acid and color measurements have clearly shown that fluctuating cycles represent changes roughly equal to those occurring at steady temperatures 3° to 6° F. above the mean, it is apparent that organoleptic procedures cannot detect changes brought about by these temperature differences except in the −10° to +10° F. range. Similar experiments with raspberries and peaches gave essentially the same results.

According to the Fechner-Weber principle, a difference in sensory response is proportional to S_2/S_1 where S_1 and S_2 are stimuli *(9)*. In the −10° to +10° F. range where the temperature coefficient is high, it would be expected that the ratio of cycle/mean temperature (−10° to +10/0° F.) would be high compared to the ratio of 10° to 30° F./20° F. or 15° to 25° F./20° F. where the temperature coefficient is much lower. Since sensory response is proportional to the value of this ratio, it is reasonable that flavor differences would be easier to detect in the low temperature ranges with high values of S_2/S_1 than in the higher ranges with relatively lower S_2/S_1 values.

DISCUSSION

Examination of the data in Figures 2, 3, 6, and 7 shows that the slope of the lines in the 0° to 10° F. range is much higher than in the 10° to 30° F. range. It is not intended to give the impression that a definite "break" occurs at 10° F. or that the data in these two temperature ranges rigidly obey an exponential relationship. Considering the nature of the material and procedures involved, however, it is believed that the steady temperature data in the −10° to +10° F. and 10° to 30° F. ranges approximate a straight line when relative rate is plotted against temperature on semilogarithmic paper. Furthermore, since the primary objective is determination of the effects of fluctuating temperatures in these ranges, the temperature coefficients of interest are those which occur over the temperature range of each fluctuating cycle. The product temperature cycles shown in Figure 1 are not precise sine waves in every respect. However, the rates obtained at fluctuating temperatures have consistently been within the experimental error of the rates obtained at equivalent steady temperatures. Changes in amplitude and frequency have given results that agreed with those predicted from theory *(9)*. That is, the effective temperature increases with the amplitude and Q_a value but is unaffected by changes in frequency. Therefore, if fluctuation *per se* caused changes other than those expected on the basis

of equivalent temperatures, they were so small that the chemical, physical, and organoleptic measurements used in these experiments were unable to detect them. It should also be emphasized that demonstration of differences between samples stored under a fluctuating cycle and samples stored at the mean temperature does not mean that fluctuation in itself causes more damage than steady temperatures. Comparisons must be made between cycle and effective temperature, and this requires a knowledge of the temperature coefficient in the fluctuating range.

SUMMARY

Storage of frozen raspberries and strawberries at steady and fluctuating temperatures in the ranges of −10° to +10°, −5° to +5°, 0° to 20°, 10° to 30°, and 15° to 25° F. has shown that the effects of fluctuating temperature can be explained on the basis of the effective steady temperature. The effective temperature is determined by the temperature coefficient in the range of the fluctuating cycle and the amplitude of the cycle. Variations in frequency of temperature cycling had no effect on rates of chemical change, provided the amplitude remained constant. Chemical, physical, and organoleptic data are presented to support the conclusion that fluctuating temperatures do not cause important changes other than those which can be predicted on the basis of steady temperatures.

Acknowledgment

The technical assistance of the following laboratory personnel is gratefully acknowledged: Margaret M. Stithem, Doris G Sweny, and A. M. Mylne.

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The Effect of Sodium Ascorbate and Sodium Iso-Ascorbate on the Quality of Frankfurters[a,b]

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THE USE of ascorbic acid and more recently, sodium ascorbate has been rather generally accepted in the sausage industry. The primary reason for their use is to assure the proper development of a cured meat color, and to provide some protection against light fading when the the meat is placed in retail display.

It has been shown by Watts and Lehmann *(6)* that ascorbic acid is generally useful in developing and maintaining cured meat color in meats containing nitrite. They have further shown that a uniform cured meat color may be achieved by either heating or freezing ground pork containing sodium nitrite and ascorbic acid. It was also observed that samples cured with ascorbic acid had a superior odor and flavor after either refrigerated or frozen storage. Bauernfeind, Smith and Parkman *(1)* reported that laboratory and plant-scale trials, as well as routine practice, demonstrated a reduced curing time, a more uniform color and a greater retention of flavor through the use of ascorbic acid in the curing process.

In the application of ascorbic acid in the curing of wieners, Brockmann and Morse *(2)* studied variations in the internal color of wieners produced with different ascorbic acid concentrations and different smoking times. In their experiments 0.05% ascorbic acid never failed to provide full color development with smoking periods of one-half hour or more. Shorter periods of heating or lower concentrations of ascorbic acid produced an inferior internal color.

Sodium iso-ascorbate is closely related to ascorbic acid and sodium ascorbate and recently has been made available commercially. It does not have the Vitamin C activity of ascorbic acid or sodium ascorbate but otherwise has much the same reaction characteristics that have made the ascorbic acid compounds useful in the curing of meats.

The Meat Inspection Division of the United States Department of Agriculture has approved the use of ascorbic acid and its derivatives in the processing of comminuted meat products, in the curing pickle of all pork and beef products, and as a protective solution on the exposed slice of prepackaged luncheon meats *(5)*.

The effectiveness of the ascorbic acid and its derivatives is attributed to its activity as a reducing agent, thus assisting in the maintenance of appropriate conditions for the development of the cured meat color.

The experiments reported here are concerned with the application of sodium iso-ascorbate to the production of frankfurters. This investigation had a two-fold purpose: first, to determine whether the processing schedules for skinless frankfurters containing sodium iso-ascorbate are sufficiently different from standard procedures to bring about a difference in the tenderness, juiciness, texture, color, flavor, or "peelability" of the product, second, to develop processing schedules for certain types of frankfurters that might be considered for guiding the commercial use of sodium iso-ascorbate.

METHODS

Three types of frankfurter emulsions were used in this study: Type A, which was an all-skeletal meat formula (boneless beef and regular pork trimming), Type B, which was an all-meat formula, containing non-skeletal as well as skeletal tissue (boneless beef, regular pork trimmings, pork hearts, pork cheeks, pork stomachs) and Type C, which contained non-fat dry milk solids and corn syrup solids to the extent permitted under Federal regulations. As nearly as possible, the meat formula for all types of product contained 40% beef and 60% pork and were prepared to produce a final composition of approximately 60% moisture, 27.5% fat, and 12.5% protein. A standard cure (3.0% NaCl, 0.5% dextrose and 0.02% nitrite) and a commercial seasoning mixture[c] were used for all types and batches of frankfurters. In the preparation of the emulsion, ground beef was first transferred to the cutter followed by one-half of the ice. The dry cure and seasoning mixture were uniformly distributed over the surface of the emulsion. After 7 minutes the pork was added to the cutter with the remainder of the ice. The cutter was stopped after 12 minutes at which time the emulsion was at a temperature of approximately 55° F. (12.8° C.). In the experimental lots ¾ ounce of sodium iso-ascorbate per hundred pounds of meat was added approximately one minute before the emulsion was removed from the chopper.

In addition to the lots of frankfurters produced containing sodium iso-ascorbate, 3 lots of the Type A frankfurter were

[a] Supported in part by a grant from Merck & Company, Inc., Rahway, N. J.

[b] Journal Paper No. 154, American Meat Institute Foundation.

[c] Supplied by Wm. J. Stange Co., Chicago, Ill.

produced containing sodium ascorbate and compared with lots containing sodium iso-ascorbate. These experimental lots were processed together. The control lots were prepared as outlined previously. The product was processed in an air-conditioned smokehouse in which temperature, relative humidity and smoke density were controlled and recorded. The primary difference in the processing schedules for the control and sodium iso-ascorbate treated frankfurters was the reduced time for the latter group. In general, the control frankfurters (no sodium iso-ascorbate) were processed for 120 to 155 minutes to an internal temperature of 155°–160° F. (69°–71° C.) at a relative humidity of 80–90%. The experimental frankfurters were processed for 75–90 minutes to similar internal temperatures at a constant relative humidity of 80%. Both groups were "smoked" for one hour at a relative smoke density of 80–90%.[4]

Under these conditions, additional moisture was added to the control frankfurters emulsions to compensate for the loss of moisture during the prolonged processing cycle. All lots were analyzed for moisture, fat and protein to determine any differences in composition between experimental and control frankfurters and to adjust for these differences. To obtain end products with comparable composition required some trial and error procedures resulting in some lots which could not be used for comparative purposes. Typical processing schedules are presented in Table 1. These schedules were those most generally used and they usually produced an acceptable product.

Samples of the frankfurters were evaluated by a taste panel of 8 members for tenderness, juiciness, texture, and flavor. The internal color was evaluated by making reflectance measurements on a cross-sectional surface using a Beckman spectrophotometer with a reflectance attachment *(3)*. The fading of the external color was determined subjectively by comparing cellophane wrapped samples exposed to light to like samples stored in the dark.

RESULTS AND DISCUSSION

Processing schedules which were found to be satisfactory for frankfurters prepared with and without sodium iso-ascorbate are given in Table 1. The time required for the control lots was found to be the minimum which would allow for adequate color development. Addition of sodium iso-ascorbate permitted a 32% reduction in processing time.

Proximate analysis, moisture protein ratios and processing time for each lot of frankfurters in the first phase of the work are presented in Table 2. With some minor exceptions, there was little difference in the final composition of the control and experimental frankfurters within lots. Table 2 also shows that 2.5–5.0% more moisture was required in the formulation of the control frankfurters to produce the same end-product analysis. The tenderness and juiciness of comminuted meat is influenced by the level of fat

[4] Smoke densitometer—Bailey Meter Co.

TABLE 1

Frankfurter processing schedule for control and experimental lots

Time period	Smoke house temperature	Relative humidity	Smoke density
(minutes)	*(degrees F.)*	*(per cent)*	*(per cent)*
Control lots[1]			
0–30	95	95	0
30–45	110	95	0
45–60	120	80	0
60–105	140	80	80–90
105–120	160	80	80–90
120–125[2]	.....	.....	.....
125–130[3]	.....	.....	.....
Experimental lots[4]			
0–15	140	80	0
15–30	140	80	80–90
30–60	160	80	80–90
60–75	170	80	80–90
75–80[2]	.....	.....	.....
80–85[3]	.....	.....	.....

[1] No iso-ascorbate.
[2] Hot shower at 170° F. (77° C.) to an internal temperature of 155° F. (69° C.).
[3] Cold shower.
[4] 7/8 oz. sodium iso-ascorbate per 100 lbs. meat.

TABLE 2

Moisture, fat, protein composition and processing time of frankfurter lots prepared with and without sodium iso-ascorbate

Type and lot number	Moisture		Fat		Protein		Added H_2O (ice) prior to processing		Processing time		Moisture/Protein	
	C[1]	E[2]	C	E	C	E	C	E	C	E	C	E
	(%)	(%)	(%)	(%)	(%)	(%)	*(% of meat)*	*(% of meat)*	*(min.)*	*(min.)*		
Type A												
1	52.0	51.9	31.6	31.5	13.1	13.5	25.0	22.5	155	90	4.0	3.8
2	56.8	58.6	25.6	24.7	14.8	13.5	25.0	25.0	130	90	3.8	4.3
3	58.5	58.5	23.3	24.5	14.4	13.6	25.0	25.0	140	90	4.1	4.3
4	59.8	60.0	23.3	23.1	13.7	13.6	28.2	25.6	150	70	4.4	4.4
5	60.0	60.4	24.5	24.0	13.6	13.6	28.2	25.6	130	85	4.4	4.4
6	58.9	60.4	25.0	23.9	13.7	13.5	28.2	25.6	135	70	4.3	4.5
7	61.3	60.7	22.4	22.9	13.1	13.4	28.2	25.6	138	70	4.7	4.5
8	54.4	53.6	30.2	31.4	11.4	11.3	25.0	22.5	125	60	4.8	4.7
9	61.2	59.3	24.4	24.8	12.2	12.9	27.5	25.0	125	70	5.0	4.6
10	62.3	60.7	23.3	24.5	12.3	12.6	28.2	25.6	130	65	5.1	4.8
11	61.7	59.7	23.7	24.5	11.6	12.5	33.3	30.8	150	70	5.3	4.8
Type B												
12	62.3	60.4	20.9	22.4	13.4	13.7	25.0	20.0	130	100	4.6	4.4
13	61.8	60.4	20.5	21.9	13.4	13.5	25.0	20.0	130	80	4.6	4.5
14	61.6	61.6	21.3	20.5	13.1	13.4	25.0	20.0	145	80	4.7	4.6
15	64.6	63.3	20.2	19.9	12.8	13.5	25.0	20.0	145	80	5.0	4.7
Type C												
16	62.8	59.6	20.8	22.3	12.0	12.2	33.3	30.8	180	70	5.8	5.4
17	60.4	58.3	22.8	22.7	12.8	12.5	33.3	30.8	150	90	5.2	5.2
18	52.9	50.5	32.0	33.5	9.8	10.7	33.0	30.8	150	90	6.2	5.3
19	52.3	52.2	32.3	32.2	10.4	10.4	33.0	30.8	150	90	5.7	5.7

[1] Control—no sodium iso-ascorbate.
[2] Experimental—7/8 oz. sodium iso-ascorbate/100 lbs. meat.

and/or moisture in relation to meat protein *(4)*. Thus, when the time required for processing is reduced through the use of ascorbic acid or one of its derivatives, processing losses are also reduced. In the present work, the anticipated processing losses were compensated for in the formulation. Under these conditions there were no significant differences in tenderness or juiciness between frankfurters containing sodium iso-ascorbate and similar products containing no ascorbate.

Average taste panel scores are recorded in Table 3. The taste panel was also asked to score the frankfurters for texture using descriptive words such as mealy, spongy, rubbery, woody and standard. These data do not lend themselves to statistical analysis but the differences indicated by the panel did not reflect any meaningful trend. The taste panel showed no preference for flavor between the paired lots indicating that neither the presence of sodium iso-ascorbate nor the reduced processing time resulting from its use, affected the flavor characteristics of the product. There were no differences in "peelability," as determined by hand peeling, attributable to the processing schedule. Peeling characteristics were satisfactory for all lots.

Table 3 also gives the average reflectance ratios for each type of frankfurter. A higher ratio indicates a brighter, more desirable color. As other workers *(2, 6)* have reported, from experiments employing ascorbic acid, the frankfurters prepared with sodium iso-ascorbate had a more uniform, more desirable internal color. All lots of frankfurters faded when held in a lighted display case. However, the controls prepared without ascorbate always appeared to fade first.

The purpose of these experiments was not to determine which type of frankfurter is preferred, but rather to determine the effect of these methods of processing on each type. Therefore a valid comparison between Types A, B and C can not be made from these data due to the experimental design.

Table 4 lists the analyses, processing time and moisture-protein ratio of those lots of frankfurters prepared for a comparison between sodium ascorbate and sodium iso-ascorbate. In these lots 5% more moisture was required in the emulsion of the control lots to produce a final product analysis comparable to the experimental lots. The reflectance ratio and taste panel scores for juiciness and tenderness are presented in Table 5. In these experiments no differences were observed between frankfurter lots prepared with sodium iso-ascorbate and sodium ascorbate. The results obtained substantiate the conclusions drawn in the first phase of the study with respect to the quality of frankfurters produced with sodium iso-ascorbate.

TABLE 3

Average taste panel scores and reflectance ratios of frankfurter lots prepared with and without sodium iso-ascorbate

	No. of judgments	Mean score		Reflectance ratios[3]
		Tenderness[1]	Juiciness[2]	
Type A				
Control	244	7.5	7.5	1.83
Experimental	245	7.7	7.3	2.05
Type B				
Control	105	7.8	7.0	1.67
Experimental	105	8.1	7.2	1.94
Type C				
Control	123	7.0	7.3	1.96
Experimental	123	7.3	7.3	2.32

[1] Tenderness rated 0–10; 0 = *tough*, 10 = *very tender*.
[2] Juiciness rated 0–10; 0 = *dry*, 10 = *very juicy*.
[3] % Reflectance 650 mμ/% reflectance 570 mμ.

TABLE 5

Average taste panel scores and reflectance ratio of frankfurter lots prepared with sodium iso-ascorbate or sodium ascorbate

	No. of judgments	Mean score		Reflectance ratio
		Tenderness	Juiciness	
Control	....	....	....	1.75
Exp. iso-ascorbate	72	7.5	6.6	1.97
Exp. ascorbate	72	7.3	6.3	1.99

CONCLUSIONS

No differences in tenderness, juiciness, texture, or flavor were observed between frankfurters prepared with and without sodium iso-ascorbate when the finished products were comparable in moisture, fat, and protein content. Frankfurters containing sodium iso-ascorbate or sodium ascorbate had a brighter, more

TABLE 4

Moisture, fat, protein composition and processing time of frankfurter lots prepared with sodium iso-ascorbate or sodium ascorbate

Lot number	Moisture	Fat	Protein	Added H_2O (ice) prior to processing	Processing time	Moisture/Protein
	(%)	(%)	(%)	(% *of meat*)	(*min.*)	
20. Control[1]	57.4	24.7	15.7	25.0	130	3.7
Exp. iso-ascorbate[2]	58.0	25.3	15.2	20.0	85	3.8
Exp. ascorbate[3]	58.0	23.3	15.1	20.0	85	3.8
21. Control	60.5	24.1	15.0	27.5	130	4.0
Exp. iso-ascorbate	62.0	22.2	15.1	22.5	80	4.1
Exp. ascorbate	63.5	20.1	14.9	22.5	80	4.2
22. Control	63.5	20.1	14.9	27.5	130	4.2
Exp. iso-ascorbate	62.1	20.3	15.0	22.5	80	4.1
Exp. ascorbate	62.3	19.0	15.0	22.5	80	4.2

[1] No iso-ascorbate or ascorbate.
[2] $\frac{7}{8}$ oz. sodium iso-ascorbate/100 lbs. meat.
[3] $\frac{7}{8}$ oz. sodium ascorbate/100 lbs. meat.

desirable, internal color than controls prepared in a similar manner. The color was more uniform, and undercured products were not found in the experimental lots. Similar results, with respect to quality and color, were obtained for each of the three types of frankfurters studied. Sodium ascorbate and sodium iso-ascorbate produced similar results for all characteristics studied. A satisfactory processing schedule for frankfurters containing sodium iso-ascorbate or sodium ascorbate is presented.

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Notes and Letters

Hot Wind Blanching — A Preliminary Statement*

IT IS DIFFICULT to achieve satisfactory dehydrated products. The art of preserving their soluble solids, texture, color, flavor, taste and rehydration power has been advanced in recent years but maintaining these qualities throughout the drying process and through storage remains a problem. Technologists have been trying hard to improve methods, equipment, and rehydration methods. They have added chemicals to help preserve color and texture. But none of these efforts has been entirely successful.

Why, with all the modern instruments, equipment and knowledge available, has so little success been attained? I believe I have some of the answers.

First, it is necessary to recognize that heat, which destroys microbes and enzymes in foods, also destroys the quality of fresh produce. Second, one should realize that the manner of applying the heat treatment has much to do with whether more benefit than damage has been done to a fresh product. Actually, one can shift the balance toward the beneficial by manipulating the methods of heat treatment.

With these precepts in mind, I began to study the various processes and to consider them separately in order to learn what each one does to the fresh product.

The blanching process. It is not possible to be fully satisfied with present scalding and blanching methods. For example, look at the appearance of fresh spinach after it has been steam blanched! Its texture is entirely destroyed. It is mushy and bleeds excessively. Its color has changed from bright yellowish green to a dark, dull green. Also look at the product you get from scalding tea leaves. Much of the soluble solids is leached out, and the tea tastes like a warmed-over, stale product. No wonder dehydrated products lose their texture, color, soluble nutrients and rehydration power! Can we prevent the damage done to these qualities before it is too late? It was with the feeling that we could, that I began to seek a new method of blanching which I call *hot wind* blanching.

THE METHOD OF HOT WIND BLANCHING (HWB)

Since air has a very low heat carrying capacity, the transfer of heat, though quick and even, is not enough to penetrate a product to great depth within short time intervals unless forced hot air at rather high pressure is used. HWB at atmospheric pressure is well suited for blanching leafy vegetables with very thin leaves, or vegetables and meats which can be cut into very thin slices, or, even better, into very fine shreds. The temperature used for hot wind blanching can be varied from 110° C. to 150° C., depending upon the thickness and nature of vegetable. But it rarely can be higher than 180° C. due to the possibility of scorching.

The wind speed used is closely correlated with the temperature employed. For temperatures of 110–150° C. the wind speed is 1,000 linear feet per minute. If the wind speed is too high, it will cause the fluffy material to break and to be blown off the trays.

Complete blanching requires from 5 to 15 minutes depending upon the thickness of product and the tray loading. For thick material, hot air at high pressure blown over the product by multiple jets, concentrating the heat at certain spots or areas, is recommended. For hams, injection nozzles blowing hot air at high pressure through the product is suggested.

DISCUSSION

As I like to repeat, one should never be satisfied with the existing scalding and blanching methods! Let us consider them.

Among the physical blanching methods, *hot water scalding* has the advantage of quick even heating. Its main handicap is: too much extraction with consequent leaching losses of soluble nutrients.

Steam or superheated steam blanching is a quick blanching method. But sudden heating by steam blanching, especially superheated steam blanching in conventional practices, causes weakening or rupture of cell walls and therefore destruction of texture and leaching of cell contents. It causes the product to become mealy and to lose rehydration power.

Contact and heat-ray methods of blanching have the common disadvantage of uneven heating; scorching of the product in contact with the heat source, or the contact surface, is almost inevitable.

THE CASE FOR HOT WIND BLANCHING

Hot wind blanching is a method which results in excellent texture, color, flavor and taste, bringing the dehydrated product a step closer to fresh produce. It preserves the integrity of cell structure.

It is a method which blanches and dehydrates at the same time. Cost of dehydration is cut to a minimum when this unit process is incorporated into tunnel dehydration.

It preserves all the soluble solids, most of the vitamins and flavor precursors. There is absolutely no leaching loss!

Evaporative cooling through HWB makes the treatment very mild, so mild as to keep the cell texture intact. It does not permit the undesirable shock of sudden heating such as steam blanching does. Evapo-

* Based on a presentation before a Seminar of the Quartermaster Food and Container Institute for the Armed Forces, Chicago, July 15, 1957.

rative cooling induced by hot wind blanching prevents that. It will not cause the rupture of cells and destruction of texture.

It gives no apparent "cooked" effect to the product. It will neither gelatinize the starch, nor coagulate the protein. The temperature of the product never reaches the gelatinizing or coagulating temperature since sufficient moisture remains to prevent gelatinization or coagulation. Rapid heating and rise of product temperature, which causes weakening or rupturing of cell walls and the collapse of product texture, does not occur in hot wind blanching.

It retains more of the water rehydration power of the dehydrated product because of the retention of texture, soluble solids and non-gelatinization of starch.

Hot wind blanching has eliminated a lot of "hard to attack" problems created by steam blanching.

SIGNIFICANCE

Since blanching is a vital process in dehydration and freezing, and also to some extent in canning, introduction of a new blanching method much better than the existing blanching methods may lead to many developments in the food processing industries, especially the tea processing industries.

Up to the present, dehydrated vegetables, especially the leafy vegetables, are not too well received by the public. In my opinion, water scalding or steam blanching has destroyed so many of their qualities as to make them unacceptable in many uses. The author can foresee that the leafy vegetable, if hot wind blanched and dehydrated, with the color, texture, flavor and dehydration power well preserved, will be able to compete with frozen vegetables in the open market on a quality basis. Hot wind blanched dehydrated vegetables would be much cheaper to produce, store, and handle and, hence, would compare favorably with frozen vegetables on a cost basis.

Some vegetables are water scalded or steam blanched before being placed in frozen storage. Hot wind blanching, applied before freezing, should definitely give a better frozen product.

In the processing of green tea, HWB will give a product with much better color (through retention of chlorophyll A) better aroma, texture and taste than the contact or steam blanched product gives. Hot wind blanching might well create a new demand and market for green tea.

T. S. Pang, M.S., Ph.D.
Professor of Food Chemistry and Technology
National Taiwan University, Taiwan

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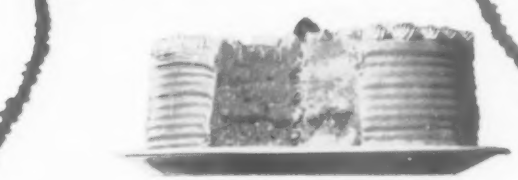

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LITERATURE OF FOOD RESEARCH AND TECHNOLOGY [1]

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[1] Material for this list should be sent to Dr. James G. Hodgson, Chief, Library Branch, Quartermaster Food and Container Institute for the Armed Forces, 1819 W. Pershing Road, Chicago 9, Illinois.

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Levels of living of U. S. farm families; selected list of references, 1940-1955.

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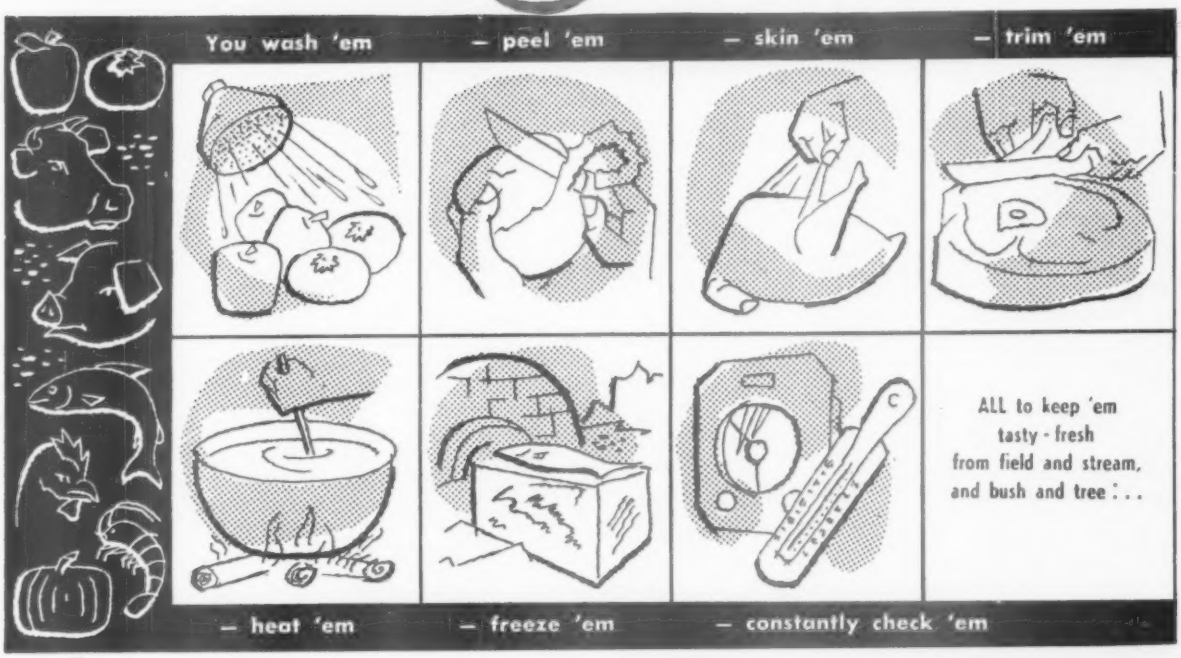
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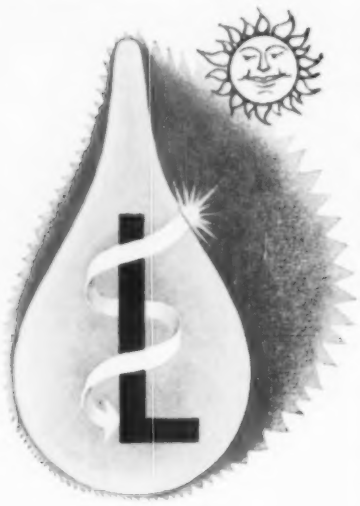

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J. R. Stanton and R. R. Mount. Washington, U. S. Govt. Print. Off., 1957. 52 p. (U. S. Department of Agriculture. Miscellaneous publication no. 746.) These and similar studies provide good justificatory material for not only nutritionists but also for food research workers with budgets to defend.

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Handbook of Russian cookery. Nina and George J. Fonds. London, Faber, 1958. 266 p. 16 s. In light of the current interest in everything Russian, this is an opportunity to check up on their food interests and habits.

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Report of a symposium on humane technique in the laboratory; held by UFAW at Birkbeck College, London, on 8th May 1957. London, 1957. 81 p. (Laboratory Animals Bureau. Collected papers, v. 6) pap. 10 s. Of interest to the food technologist who uses animals in experimentation. Obtainable from Laboratory Animals Bureau, M. R. C. Laboratories, Holly Hill, Hampstead, London, W. C. 3, England.

ABSTRACTS

—Compiled by H. A. Campbell

ANALYTICAL METHODS

Two-stage gas liquid chromatography.

SIMMONS, M. C. AND SNYDER, L. R. (Houston Research Lab., Shell Oil Co., Houston, Texas). *Anal. Chem. 30,* 32–5 (1958).

An instrument arrangement has been devised for connecting 2 or more gas-liquid chromatographic columns in such a manner that preliminary cuts prepd. by first column can be charged directly to one or more secondary columns. This shortens total time of analysis and permits sepns. and analyses not possible with a one-stage unit.

Selectivity of various liquid substrates used in gas chromatography.

TENNEY, H. M. (Esso Research Labs., Baton Rouge, La.). *Anal. Chem. 30,* 2–8 (1958).

Gas chromatography can be applied successfully to many problems only if there are at hand an assortment of column packings having wide differences in selectivity. In this study, 18 liquid substrates have been screened as to selectivity toward types of hydrocarbons and oxygenated compds. The results permit comparison of retention between compd. types at various boiling point levels.

Exploratory studies of high temperature gas-liquid chromatography.

OGILVIE, J. L., SIMMONS, M. C., AND HINDS, G. P. (Houston Research Lab., Shell Oil Co., Houston, Texas). *Anal. Chem. 30,* 25–31 (1958).

A gas-liquid chromatography system has been designed, which is capable of operating up to about 400° C. With its higher mol. wt. sepns. are made possible by use of asphaltenes as stationary liquid phase and bare-wire thermal conductivity filaments in detector cell. Technique has been used for detn. of *n*-paraffin distribution in waxes.

Determination of five- to seven-carbon saturates by gas chromatography.

EGGERTSEN, F. T. AND GROENNINGS, S. (Shell Devel. Co., Emeryville, Calif.). *Anal. Chem. 30,* 20–4 (1958).

A blend of 25 C_5 to C_7 saturates can be analyzed for all components (except 3-ethylpentane) by gas chromatography using 3 different types of columns. Results agree well with API cooperative testing of same sample by other means. Three-column analysis can be made in 12 to 16 hrs. of elapsed time.

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Mass spectrometry in chemical research and production.

McLafferty, F. W. (Spectroscopy Lab., The Dow Chem. Co., Midland, Mich.). *Appl. Spectroscopy 11*, 148–56 (1957).

The mass spectrometer is uniquely applicable to the soln. of a wide range of problems in chem. research and production. Plant stream analyzers now available enhance its advantages for rapid accurate quant. analyses of mixts. of a large no. of components. Unique information concerning identity or mol. structure is obtainable from a mass spectrum, complementing well present instrumental methods such as infrared spectrophotometry. Illustrations are given to show the broad potentialities of the technique. A method of classification and mechanisms of formation are discussed for the anomalous mol. rearrangements found in many spectra.

Determination of vitamin A by conversion to anhydrovitamin A.

Budowski, P. and Bondi, A. (Agr. Research Sta., Rehovot, Israel). *Analyst 82*, 751–60 (1957).

Vitamin A may be converted to anhydrovitamin A in benzene soln. at room temp., in the presence of toluene-*p*-sulphonic acid as a catalyst. The increase in extinction at 399 mμ, which results from the dehydration, is proportional to the amt. of vitamin A present and can be used for the detn. of this vitamin in unsaponifiable exts. The method exhibits a high degree of specificity and has been applied to a variety of products, including vitamin-A concs., fish oils, margarine, butter and poultry mashes, without further purification of the unsaponifiable exts.

BIOLOGICAL SCIENCES

Biochemistry

Mechanism of browning of ascorbic acid-citric acid-glycine systems.

Lalikainen, T., Joslyn, M. A. and Chichester, C. O. (Dept. of Food Technol., Univ. of California, Davis). *J. Agr. Food Chem. 6*, 135–8 (1958).

To det. whether Strecker degradation of amino acids occurred in the browning of orange juice, the browning of ascorbic acid in citrate-buffered solns. contg. radioactive glycine was studied. Neither Schiff bases nor volatile aldehydes were detected. Less than 3% of the CO_2 evolved was derived from glycine-C_1; less than 0.1% from glycine-C_2. The data indicated that the Strecker degradation does not occur, in detectable degree, under the test conditions. The browning of this system, therefore, does not follow the usual pathways reported for the glucose-glycine system.

Metal activated hydrolysis of bonds of biological significance.

Campbell, M. J. (Northwestern Univ., Chicago, Ill.). *Dissertation Abstr. 17*, 2790 (1957).

The hydrolysis of glycyldehydrophenylalanine was investigated in the presence of dehydropeptidase and in neutral aq. solns. of copper salts at 100° C. Intermediate formation was indicated by a shift in absorption peak during the course of the reaction. In aq. soln. in the absence of enzyme, glycyldehydrophenylalanine formed a complex with copper at pH 8.0. It seems that in the enzymatic reaction, the intermediate is the peptide-zinc-protein complex. The exptl. work presented is interpreted to provide mechanisms for the metal activated hydrolyses of peptide, disulfide, and amino acid ester bonds.

Oxidized fatty acid-protein complexes.

Narayan, K. A. and Kummerow, F. A. (Dept. of Food Technol., Univ. of Illinois, Urbana). *J. Am. Oil Chemists' Soc. 35*, 52–6 (1958).

Complexes have been formed between egg albumin and oxidized linoleic acid. Little or no complex formation could be obtained with unoxidized linoleic acid, oleic acid, or laurie acid. The amt. of complexed linoleic acid could not be increased to more than 8.0% in spite of a long reaction time. The no. of reactive groups (amino, sulfhydryl, and hydroxyl) in the protein of the complexes and in the original protein were found to be the same. The data seemed to indicate that a covalent linkage did not exist between the reactive groups of the protein and the lipide in the complexes of this type.

A new naturally occurring isomer of β-methyllanthionine.

Downey, P. F. and Black, S. (Natl. Inst. of Arthritis and Metabolic Diseases, Natl. Insts. of Health, Bethesda, Md.). *J. Biol. Chem. 228*, 171–9 (1957).

A new sulfur-contg. amino acid has been isolated from yeast which has the empirical formula $C_7H_{14}O_4N_2S$. It is distinguished from known compds. having the same formula, such as 4 cystathionines, by its specific rotation, +37.6°, and other properties. It is concluded that the compd. is one of the 2 theoretically possible isomers of β-methyllanthionine which contain residues of L-alanine and D-α-amino-α-butyric acid. This compd. is one of an apparently large number in yeast which becomes labeled with S^{35} when the cells are incubated with $CH_3S^{35}H$.

The preparation of glucosamine oligosaccharides. I. Separation.

Horowitz, S. T., Roseman, S. and Blumenthal, H. J. (Depts. of Biol. Chem. and Bacteriol., Univ. of Michigan, Ann Arbor). *J. Am. Chem. Soc. 79*, 5046–9 (1957).

Chitosan was partially degraded by the use of HCl. The hydrolysate was fractionated by means of ion-exchange chromatography and yielded 5 discrete peaks. Analysis indicated that the materials in the peaks were glucosamine oligosaccharides which were eluted in order of increasing mol. wt. Procedures are presented for the analysis of glucosamine oligo- or polysaccharides and for large scale gradient chromatography.

Microbiology

Lethal effect of visible light on a mutant strain of haploid yeast. II. Absorption and action spectra.

Elkind, M. M. and Sutton, H. (Natl. Cancer Inst., Natl. Insts. of Health, Bethesda, Md.). *Arch. Biochem. Biophys. 72*, 96–111 (1957).

Evidence has been presented which shows that SC-7 (ρ) in the course of developing light sensitivity also generates a pigment demonstrable by difference spectroscopy with whole cells. The results of the action spectrum study are consistent with the view that this new cell pigment is responsible for the absorption and consequent action. Although the peak locations and general shape of the spectrum are reminiscent of the third complexes of catalase or peroxidase, attempts to strengthen the identification of either of these enzymes were not conclusive.

Observations on the individuality of yeast maltases.

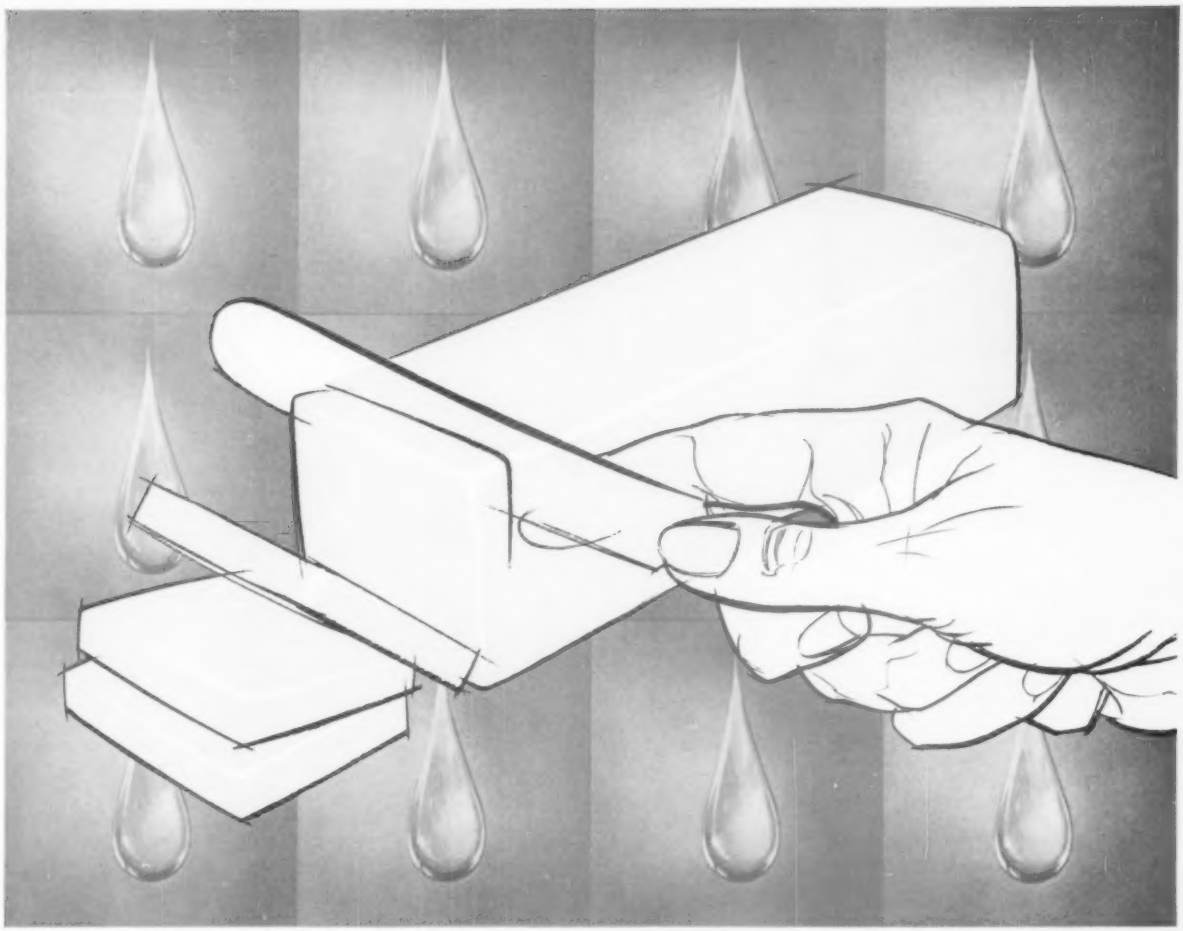
Cook, A. H. and Phillips, A. W. (Brewing Ind. Research Foundation, Nutfield, Engl.). *Arch. Biochem. Biophys. 69*, 1–9 (1957).

The hydrolytic action of cell-free exts. of 2 species of the genus *Saccharomyces* toward maltose and maltotriose has been examd. using paper chromatography. Maltose and maltotriose were rapidly attacked by enzymic prepns. from *Saccharomyces cerevisiae*, only maltose was hydrolyzed when similar exts. from *Saccharomyces uvarum* were employed.

Viral invasion. II. The role of zinc in bacteriophage invasion.

Kozloff, L. M., and Lute, M. (Dept. of Biochem., Univ. of Chicago, Ill.). *J. Biol. Chem. 228*, 529–36 (1957).

Isolated cell walls of *Escherichia coli* B each contain about 3100 zinc atoms. The removal of the zinc by acid extn. does not affect the ability of the cell wall to adsorb irreversibly T2 and T4 bacteriophages. Acid-extd. cell walls can be enzymatically digested by altered phage but not by intact phage. Preincubation of acid-extd. cell walls with Zn^{++} (5×10^{-7} *M*) restores the ability of intact phage to digest the cell walls. Preincubation with other metals (Cd^{++}, Hg^{++}, etc.)



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does not have this effect. It is proposed that, during bacteriophage invasion, the bacteriophage tail comes in contact with a zinc protein in the cell wall which ruptures thiol ester bonds in viral tail and exposes the viral tail enzyme.

Viral invasion. III. The release of viral nucleic acid from its protein covering.

Kozloff, L. M. and Lute, M. (Dept. of Biochem., Univ. of Chicago, Ill.). *J. Biol. Chem. 228*, 537–46 (1957).

T2 bacteriophage whose tail structure has been altered by treatment with cadmium cyanide complexes has been used as a model to study factors affecting the release of viral deoxyribonucleic acid (DNA) from the protein coat. The release of the viral DNA through the tail is dependent upon the temp. and the presence of compds. which possess a primary amino group, such as various amino acids and glucosamine. These compds. cause the release of all the viral nucleic acid within 2 minutes at 37°. The release occurs optimally at pH 8.75 to 9.0.

Biphasic system for growing bacteria in concentrated cultures.

Tyrell, E. A., MacDonald, R. E. and Gerhardt, P. (Dept. of Bacteriol., Univ. of Michigan, Ann Arbor). *J. Bacteriol. 75*, 1–4 (1958).

The concn. of masses of pathogenic bacteria can be simplified by growing them in a confined environment with diffusional access to a reservoir of nutrients. Culturing them on an agar or membrane surface accomplishes this; however, the total cell yield often is low, the cells probably are not physically uniform, and difficulty may occur in dislodging them. The concn. of cells or their products also may be obtained in a liquid medium by using a cellophane sac to sep. the culture from a large nutrient supply. A combination of these principles led to the idea of concentrating bacteria in a biphasic growth system that consists simply of a layer of solid nutrient medium overlaid with a small vol. of nutrient broth.

Nutrition

Nutritional requirements of the dog.

Ontko, J. A. (Univ. of Wisconsin, Madison). *Dissertation Abstr. 17*, 2143 (1957).

The effects of various dietary supplements on reproduction and lactation performance of dogs fed a 20% casein, purified ration were investigated. Dogs fed the basal purified ration failed to reproduce normally as evidenced by the high mortality rate of the newborn within 2 days after birth. This mortality was markedly reduced by 5% addnl. dietary protein. During gestation and lactation the caloric requirement of dogs which weaned 5 or more pups was resp. 1.2 and 2.8 times that required during maintenance. Pups in small litters were heavier at birth and grew faster than pups in large litters. The fastest rate of growth for newborn pups occurred during the second week, after which the growth rate decreased. Increased fat in the diet increased the protein requirement as measured by growth rate and feed efficiency for weanling pups. A 30% fat diet was found to require 29% protein.

Effects of protein per calorie ratio and dietary level of fat on calorie and protein utilization.

Yoshida, A., Harper, A. E. and Elvehjem, C. A. (Dept. of Biochem., Coll. of Agr., Univ. of Wisconsin, Madison). *J. Nutrition 63*, 555–69 (1957).

The effects of changes in the protein per Calorie ratio of the diet and in the level of dietary fat on growth, body gain per Calorie consumed and body gain per g of nitrogen consumed have been examd. using young rats fed on diets contg. casein as the source of protein. The evidence obtained indicated that the fat content of the diet influenced neither the percentage of ingested nitrogen retained nor the efficiency of calorie utilization. There did appear to be some transitory beneficial effect of addnl. fat in stimulating food consumption and growth during the 1st week of the expt. when the protein per Calorie ratio was held const.

Effect of level of protein intake and of age of rat on the biological value of proteins.

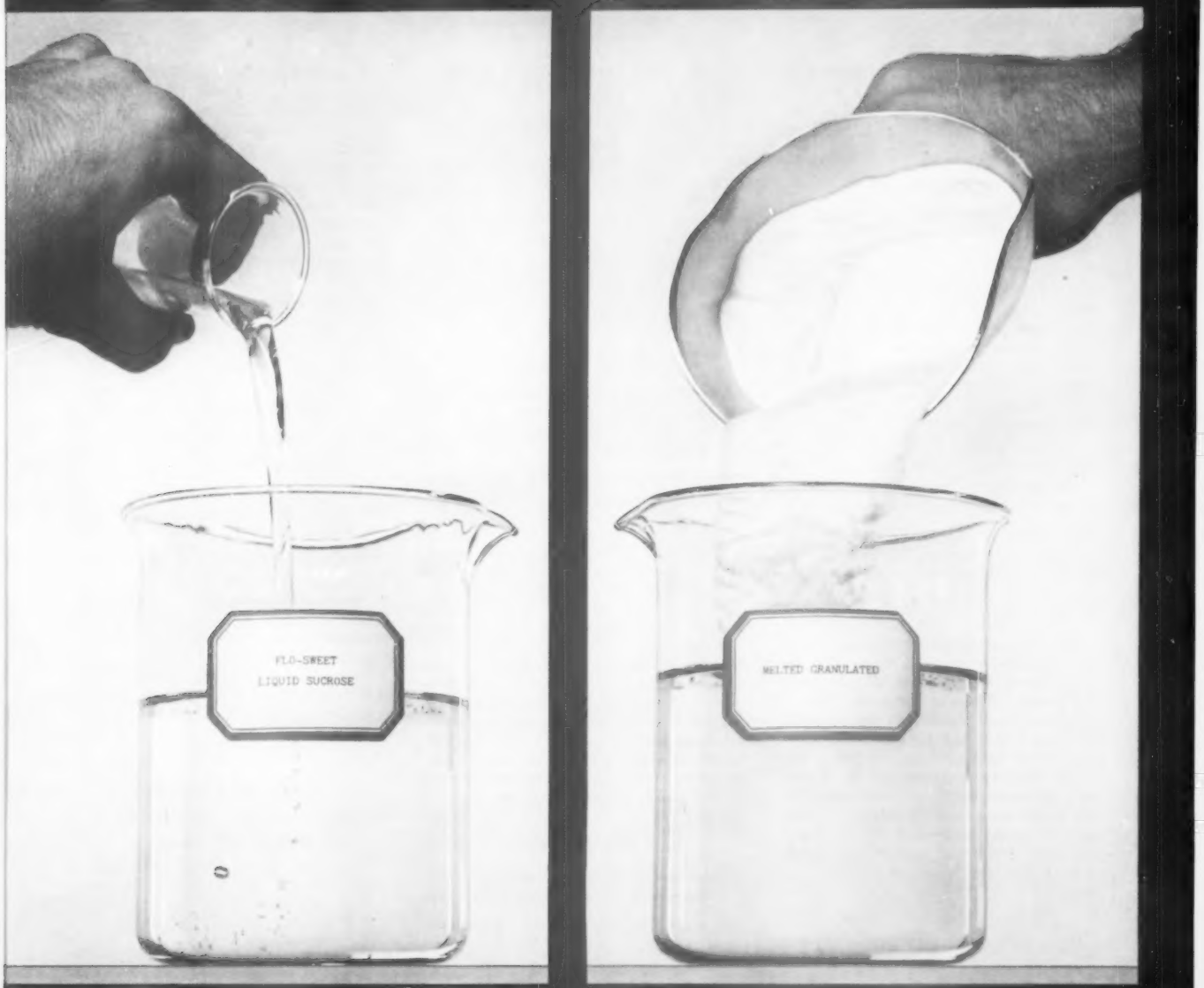
Henry, K. M. and Kon, S. K. (Natl. Inst. of Research in Dairying, Shinfield, Engl.). *Brit. J. Nutrition 11*, 305–13 (1957).

The authors conclude that the requirements of both protein and sulphur amino acids for the maintenance of nitrogen balance decreases with age. A higher biol. value (85) for casein was obtained with adult rats, than with young rats (77). Since the amino acid requirements vary with age, different biol. values are obtained at various levels of protein in the diet.

The effects of biologically unavailable lysine (heated casein) on growth. I. Body weight and bone growth.

Koyoumdjisky, E. (Faculty of Med., Columbia Univ., New York). *J. Nutrition 63*, 509–20 (1957).

A temporary growth cessation, expressed in lowered body wt. takes place in animals fed adequate diets in which the sole source of protein is heated casein. The imbalance produced by the diet induces a uniform retardation in the formation of both skeletal and soft structures, under the conditions in which this expt. was carried out. The changes occurring during the period of retardation are reversible and self-correcting without supplementation of the diet.



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Studies of various nutritional factors in relation to dental caries in the rat. II. The anticariogenic effect of oat hulls.

TAKETA, F. (Univ. of Wisconsin, Madison). *Dissertation Abstr. 17*, 2146 (1957).

Oat hulls incorporated into some cariogenic diets reduced caries incidence and extent upwards of 50%. Possibly all of the activity can be extd. in hot EtOH or aq. base soln. and recovered in the extd. solids. The EtOH extractable activity was assocd. with the acidic fraction, and related to the lactobacillus assay. Saturated fatty acids and phenolic acids present in oat hulls have been found to inhibit the growth of *L. acidophilus* and oral microflora.

Effect of partial pantothenic acid deficiency on reproductive performance of the rat.

BARBORIAK, J. J., KREHL, W. A., COWGILL, G. R. AND WHEDON, A. D. (Dept. of Biochem., Yale Univ. School of Med., New Haven, Conn.). *J. Nutrition 63*, 591–8 (1957).

The effect of long-term feeding of suboptimal amts. of pantothenic acid on the reproductive performance of the male and female rat was investigated. Serious anatomical and functional impairments of testes with resulting loss of fertility was noted in male rats receiving the lowest vitamin supplement. In female rats, decreased fertility, little resorption and malformation, and retarded development of young were observed on the 2 lowest vitamin levels, without any significant concomitant histological changes in the ovaries.

Toxicology

Toxicologic evaluation of gibberellic acid.

PECK, H. M., MCKINNEY, S. E., TYTELL, A. AND BYHAM, B. B. (Sharp & Dohme Research Labs., West Point, Pa.). *Science 126*, 1064 (1957).

Fifty-four white rats were fed a diet contg. 5.0% gibberellic acid for periods of 5 and 8 weeks. Gross and histo-morphologic studies of the various tissues did not reveal lesions or alterations that could be attributed to the administration of gibberellic acid. The present evidence indicates that the agent presents no apparent hazard either to the individual who uses the material for agr. purposes or to individual who consumes products on which gibberellic acid or salts have been used.

FOOD AND FOOD TECHNOLOGY

Baking and Bakery Products

The use of solid triglyceride stearines as fluid shortening ingredients.

LINTERIS, L. L. AND THOMPSON, S. W. (Lever Bros. Co., Edgewater, New Jersey). *J. Am. Oil Chemists' Soc. 35*, 28–32 (1958).

The addn. of substantially insol., solid triglycerides in very finely divided form to liquid oils, with the object of improving their cake performance but not destroying fluidity, has been studied. Stearines made from rapeseed and mustardseed oils and certain peanut-oil fractions possessed the desired properties. The effective triglycerides in these stearines were of the monobehenodistearin and stearopalmitobehenin type.

Coffee and Tea

Effect on certain ion combinations commonly found in potable water on rate of filtration through roasted and ground coffee.

GARDNER, D. G. (United States Testing Co., Inc., Hoboken). *Food Research 23*, 76–84 (1958).

The effect of water compn. on prepn. time in percolation system, was studied. The investigations showed that most of the ions present in many water supplies change the brewing time only slightly. However, the presence of carbonate or bicarbonate ions increases this time significantly and in direct relation to their concn. This effect is accentuated by sodium ions if water, contg. temporary hardness and softened in a zeolite conditioner, is used. Water, classified as permanently hard, whether treated or not, had little effect on prepn. time.

Fats and Oils

Studies on the nutritional and physiological effects of thermally oxidized oils.

JOHNSON, O. C., PERKINS, E., SUGAI, M. AND KUMMEROW, F. A. (Dept. of Food Technol., Univ. of Illinois, Urbana). *J. Am. Oil Chemists' Soc. 34*, 594–7 (1958).

The present results indicated that the thermal oxidation products from the polyunsatd. fatty acids, primarily linoleic acid, are responsible for much of the loss of nutritional value in thermally oxidized edible oils. Oils which have a high linoleic acid content are more likely to undergo thermal oxidative damage than those with lower linoleic contents. The products formed during thermal oxidation which cause the loss of nutritional value are those which do not form urea-inclusion compds. They are probably polymeric in nature, but thermally oxidized oils also contain carboxylic acids and carbonyl groups. The rate of *in vitro* hydrolysis of the thermally oxidized corn oil by pancreatic lipase, also the rate of absorption from the intestine of the male rats, were found to be decreased.

Direct determination of saturated fatty acids in fats, oils, and methyl esters.

KUEMMEL, D. F. (Procter and Gamble Co., Miami Valley Labs., Cincinnati). *J. Am. Oil Chemists' Soc. 35*, 41–5 (1958).

A direct gravimetric method has been developed for the detn. of satd. fatty acids in fats, oils, and methyl esters. The procedure involves methanolysis of the triglycerides to produce methyl esters, followed by oxidation of the unsatd. methyl esters by potassium permanganate. The undesired, acidic oxidation products are removed by alk. washing and the satd. methyl esters thus isolated are weighed directly. The method is intended for the detn. of satd. fatty acids having C_{16} or longer carbon chains. Replicate detns. on samples in the 10 to 30% saturates range gave a standard deviation of 0.3 to 0.4%.

Flavors and Flavoring

Taking a "new look" at our odor, flavor transfer problems.

BROCKINGTON, S. F. (Research Lab., Quaker Oats Co., Barrington, Ill.). *Package Eng. 3*, 27–36 (Jan. 1958).

The author reviews methods of detecting relations of food flavors and aromas to packaging materials. Greater sensitivity of trained sniff and taste testers is stressed over instrumental measurements. Odors contributed by packaging materials cannot be neglected. Bibliography was prepd. by Quaker Oats lab. librarian and Amer. Can Co. research labs. 64 references.

Fruits and Vegetables

Flavonoids of citrus. II. Isolation of a new flavonol from lemons.

HOROWITZ, R. M. (Western Utilization Research and Devel. Div., Pasadena, Calif.). *J. Am. Chem. Soc. 79*, 6561–2 (1957.)

The complex mixt. of aglycones, obtained from the enzymatic hydrolysis of the flavonoid glycosides of lemon peel, deposited on standing a cryst. flavonol identified in this expt. as dimethoxytetrahydroxyflavone. It is the first representative of this flavonol to be found in citrus and has been named limocitrin. The location of the methoxy groups were shown to be at the 3′ position and the 8 position. It is concluded that the structure of limocitrin is 3′,8-dimethoxy-3,5,7,4′-tetrahydroxyflavone. The structure was confirmed by various spectral measurements.

Enzyme action and off-flavor in frozen peas.

WAGENKNECHT, A. C. AND LEE, F. A. (New York State Agr. Expt. Sta., Cornell Univ., Geneva). *Food Research 23*, 25–31 (1958).

The addn. of enzymes to blanched peas resulted in the production of off-flavors following frozen storage. Lipoxidase-treated samples were moderately off-flavored. Catalase and peroxidase produced only mild changes in flavor. Lipase-treated samples possessed disagreeable off-flavors, which must be attributed

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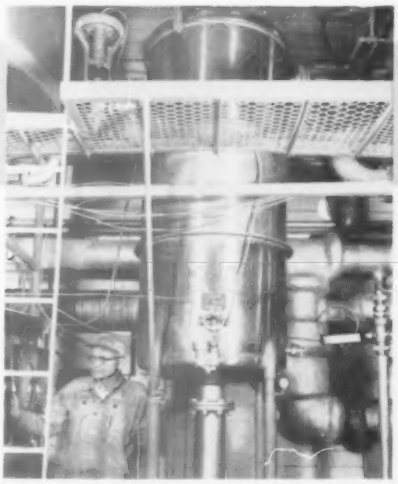

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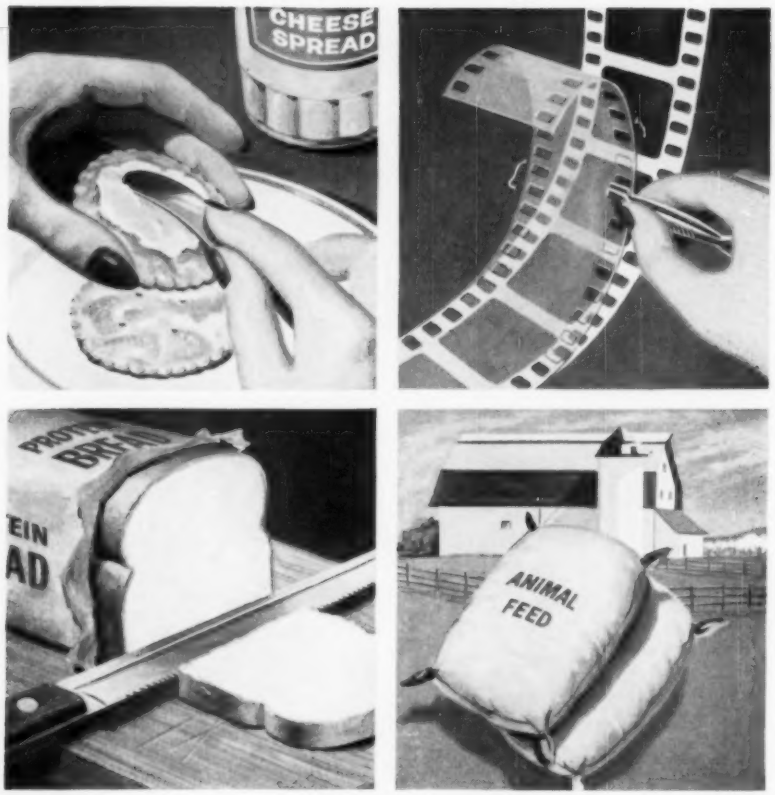

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in part to the flavor imparted by the lipase prepn. itself. Changes in green color were produced by the addn. of all 4 of these enzymes. Lipase caused the greatest losses of chlorophyll, evidenced by the formation of pheophytin. A possible mechanism by which lipase may function in off-flavor development has been proposed.

Gelatin

The cross-linking of gelatin using a water-soluble carbodiimide.

SHEEHAN, J. C. AND HLAVKA, J. J. (Dept. of Chem., Massachusetts Inst. of Technol., Cambridge). *J. Am. Chem. Soc. 79*, 4528–9 (1957).

Treatment of an aq. gelatin soln. with a water-soluble carbodiimide resulted in very rapid gelation, shown to be due to amide bond formation. If the gelled soln. of gelatin and carbodiimide is heated immediately on a steamcone for 10 minutes, the mixt. remains solid at the elevated temp. and on storage for 5 days at 25°. Liquefaction is considered to be assocd. with phase-sepn., and the phenomenon is being investigated further.

Recent advances in the enzymatic hydrolysis of pectic substances.

DEMAIN, A. L. AND PHAFF, H. J. (Dept. of Food Technol., Univ. of California, Davis). *Wallerstein Lab. Commun. 20*, 119–37 (1957).

This review has emphasized the complexity of the enzyme systems capable of glycosidic hydrolysis of pectic substances and an attempt has been made to classify the pectic enzymes described under a great variety of names into a simple logical system. The proposed classification makes use of the preferred substrate (highly esterified pectin versus pectic acid), mechanism of attack (random splitting versus end group attack), optimum pH and extent of hydrolysis of the polyuronide chain. The present status of protopectinase and classical fungal polygalacturonase has been discussed critically. In addition, the current knowledge of microbial and plant pectinesterases has been reviewed as well as certain applications of pectic enzymes in the light of the newer knowledge.

Pesticides

Testing pesticide emulsions.

BEHRENS, R. W. (Atlas Powder Co.). *J. Agr. Food Chem. 6*, 20–4 (1958).

Five variables frequently encountered in preparing emulsions are, the ratio of emulsifiable concentrate to water, hardness of the water, amt. and kind of mixing, quantity of emulsifier, and temp. of ingredients. Characterizing emulsions by centrifuging, particle size distribution, light transmission, chem. analysis, or changes in sp. gr. are time-consuming. A

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successful method used in pesticide emulsions which may be applied to other fluid emulsions is the observation on the rate of creaming. Observation may be made on emulsions in unetched tubes with a light issuing from behind to det. the depth of emulsion or rate of creaming.

Comparative biochemical aspects of insecticidal action.

WINTERINGHAM, F. P. W. (D.S.I.R. Pest Infestation Lab., Bucks, Engl.). *Chem. and Ind. 56*, 1195–201 (1957).

The biochem. and phys. differences between mammals and insects are exaind. for evidence of a basis for selective insecticidal action. There is evidence of differences in sensitivity of enzymes common to both insects and mammals; and evidence of mechanisms found in insects, which are not shared by mammals. Mechanisms of action of toxic substances in mammals and insects are described.

Potatoes

Effect of non-antiscorbutic reducing substances upon the ascorbic acid content of baked potatoes.

MCAFEE, J. W. AND WATTS, J. H. (The Carver Foundation, Tuskegee Inst., Alabama). *Food Research 23*, 114–18 (1958).

On measuring the ascorbic acid content of potatoes baked to a series of internal temps. between 45° C. and 90° C., it was observed that there is a decrease in ascorbic acid content at the beginning of the baking period and thereafter, an increase. The retention of reduced ascorbic acid in baked sweet potatoes, as detd. by the indophenol method, was 109%. The retention of total ascorbic acid—reduced + dehydro—in baked white potatoes was 174%. Dehydration at high temps., which occurs during baking, might be the causative factor in the formation of these non-antiscorbutic reducing substances. Data obtained by 3 different methods emphasize the importance of having a suitable method for making ascorbic acid analyses.

Preservation

Symposium on antimicrobial preservatives.

GRUBB, T. C. (Vick Chem. Co., New York, N. Y.). *Bacteriol. Rev. 21*, 251–6 (1957).

While a variety of destructive influences assail manufd. products this symposium is concerned only with the role of the microbe in producing destructive changes. By definition, an antimicrobial preservative does not contribute anything to the efficacy of the product and thus some manufacturers are loath to spend appreciable amts. of time and money on the study of antimicrobial preservatives, *per se*. The regulatory aspects of preservatives in foods, drugs and cosmetics were reviewed. Sections of the Food and Drug Act of 1938 which pertain to preservatives in foods were explained.

INDUSTRY PUBLICATIONS

Continental Can Co., Inc. has recently released **Fact Sheet B,** revision No. 3, which covers research and engineering by the company. It presents history as well as development of such product lines as metal cans with plastic nozzles, fibre drums that hold liquids, the White twist-off cap, folding cartons that protect contents from corrosion and rancidity, and, last of all, cans made from aluminum.

A new eight-page brochure describing the types of nitrous oxide installations designed specifically for the **pressurized packaging** industry is available from Ohio Chemical & Surgical Equipment Co., 1400 E. Washington Ave., Madison 10, Wis. An outline of the manufacturing processes, filling procedure and standards are included. Requests should be made for Form 4774.

"Slip Without Soil" is the title of a new folder on conveyor lubrication recently published by Oakite Products, Inc. The folder points out problems involved in chain lubrication and describes varying advantages of four Oakite lubricants designed for this work. Folder is F-10347 from company at 157 Rector St., New York 6, N. Y.

A re-issue of **"Corn Starch,"** the 44-page booklet produced by the Corn Industries Research Foundation, Inc., is now available. It has been updated from the previous text issued in 1955. It can be obtained free on request to the foundation at 1001 Connecticut Ave., N.W., Washington 6, D. C.

A new four-page bulletin has been issued by the J. H. Day Co., division of the Cleveland Automatic Machine Co. It describes the Day **Three-Roll Dispersion Mills** for all types of materials, flowing or paste, including many products, such as soaps, ointments, chocolate and heavy pastes. A copy may be obtained by writing the manufacturer at 4932 Beech St., Cincinnati 12, Ohio.

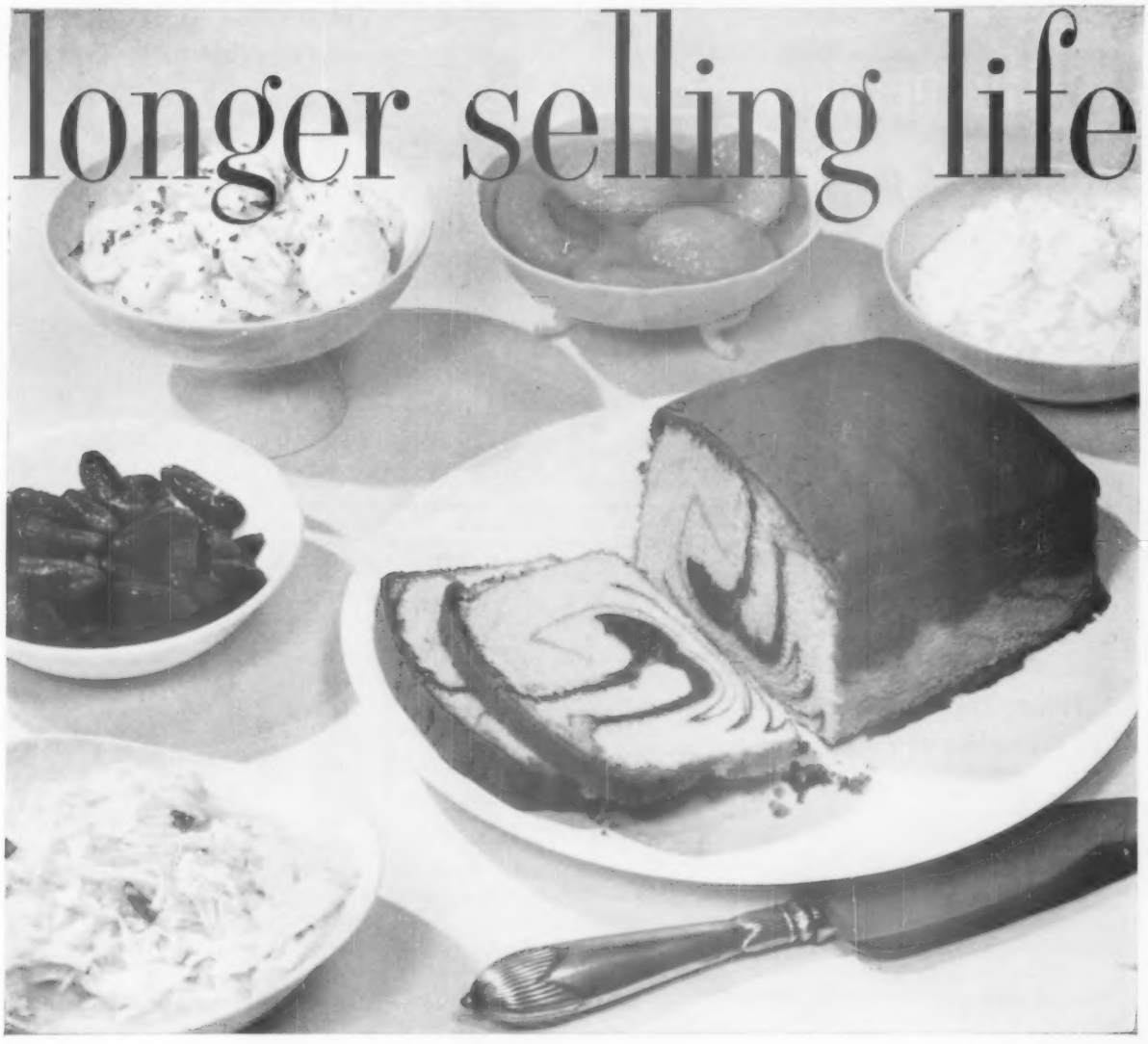
PERSONNEL

Francis T. Murray has recently been appointed director of advertising, public relations and sales promotion for the Crown Cork and Seal Co., Inc. Previously he served as director of intercollegiate athletics at the University of Pennsylvania.

Several key appointments were recently announced by the recently formed Girdler Process Equipment Division of National Cylinder Gas Co. **Bruce D. Miller** has been named vice president of manufacturing; **Allen M. Bond, Jr.,** director of engineering and product development, and **N. T. Joyner,** general sales manager.

Carl H. Haurand, a member of IFT, was recently elected a director of The Best Foods, Inc. He fills a vacancy on the board created by the retirement of Jerome M. Rosefield. Mr. Haurand has been with the firm since 1927, and was most recently elected vice-president of manufacturing.

Paul J. Cardinal, vice-president in charge of industrial relations for Hoffmann-La Roche Inc., has



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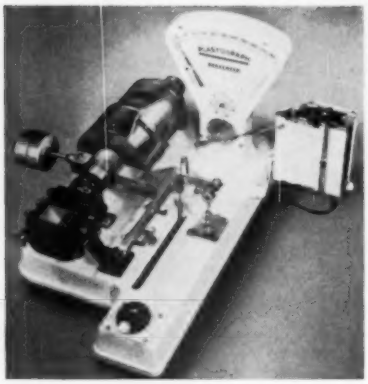

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Pictured inspecting trays of fudge during a meeting of the Research Committee of the National Confectioners' Association held recently at the Southern Utilization Research and Development Division of the Agricultural Research Service, USDA, New Orleans, La., are, left to right: John M. Whittaker, New England Confectionery Co., Cambridge, Mass.; Philip P. Gott, president of NCA; O. B. Elmer, Elmer Candy Co., New Orleans, and Dr. L. F. Martin, Head, Sugarcane Investigations, SURDD.

been elected a vice-president of the National Vitamin Foundation, Inc. At the same time he was re-elected to the Board of Governors, a post which he has held for the past year.

Dr. Lloyd A. Hall, Technical Director, The Griffith Laboratories, Inc., Chicago, was voted the Honorary Membership Award of The American Institute of Chemists at the 35th Annual Meeting of the Institute at the Ambassador Hotel, Los Angeles, California, April 9 to 11th. He was also re-elected for a three-year term to the Board of Directors. Dr. Hall is a Charter Member of the Institute of Food Technologists and has been active in its affairs for many years.

B. F. Buchanan

Dr. Ben F. Buchanan has been named associate director of product development of the General Foods Research Center, it was announced recently. Dr. Buchanan, an IFT member, will be in charge of development of new products and processes, the improvement of quality and processes, the investigation of new raw materials, and development of by-products. He is a member of the American Chemical Society, American Association for the Advancement of Science, American Association of Cereal Chemists, New York Academy of Sciences, and the Chemists Club of New York.

William J. Scarlett has been named general manager of Lee Metal Products Co., Inc., it has been announced by J. Munson Lee, president. The appointment was effective May 1st.

W. J. Scarlett

Formerly Food Industry manager of Brown Instruments Division of Minneapolis-Honeywell, Mr. Scarlett succeeds George H. Tay, Sr., vice president and general manager since Lee Metal Products was founded in 1928. Mr. Tay is

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Mr. Gene Lane, Utility Operator, at the Central Soya Co., Inc., Chattanooga, Tenn. plant, operates 36 Merchen Scale Feeders that blend feed ingredients to 1% accuracy.

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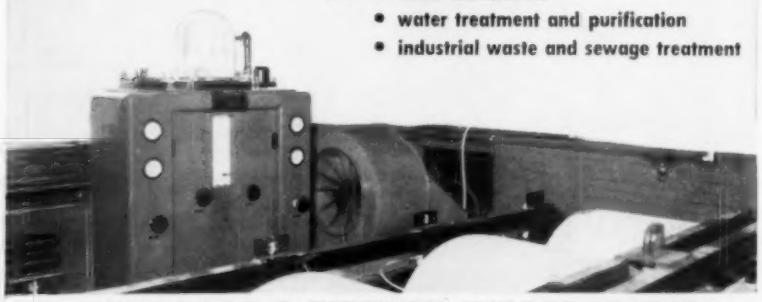

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retiring from active duty due to ill health, however he will retain his title of vice president and will be available as a consultant.

Mr. Scarlett has been with Minneapolis-Honeywell in Philadelphia since 1951. Prior to that he had been associated with Wallace and Tiernan, Inc., General Electric Company, Hershey Chocolate Corporation, Frigidaire Division of General Motors Corporation and The Carrier Corporation.

Methods of extracting and processing cottonseed oil and other edible oils, and their effect on the quality of the final product, interested Mr. Agne Johnsson, right, a recent visitor at the Southern Utilization Research and Development Division of the Agricultural Research Service, USDA, in New Orleans, La. Mr. Johnsson, an engineer with Aktiebolaget Karlshamns Oljefabriker, Karlsham, Sweden, inspected the pilot-scale filtration-extraction equipment, and learned about details of the process, which was developed by research workers at SURDD. Pictured with Mr. Johnsson is Dr. E. F. Pollard, Head of Industrial Analysis Investigations of the Engineering and Development Laboratory, SURDD. The Swedish margarine industry is highly conscious of quality factors in vegetable oils, and representatives visiting in this country have been interested in effects of various processing methods on these factors.

W. E. Townsend

Dr. William E. Townsend, a native of Island Falls, Maine, has joined the staff of the Research Laboratories of Swift & Company. Dr. Townsend's doctorate in Animal Husbandry was awarded this year at Michigan State University.

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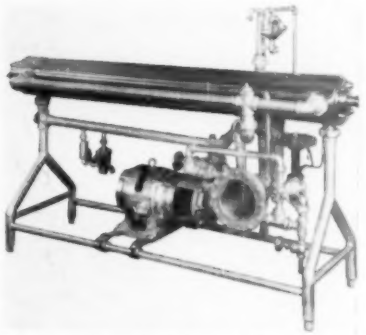
EQUIPMENT

Corning Glass Works has announced that it is now producing **Pyroceram tubing and plate** for commercial use. This crystalline material that was recently tested for use as a guided missile nose cone is currently undergoing tests in heat exchangers. Other commercial applications being investigated include bearing parts for high temperature use, piston heads, precision made aircraft structural parts, and like uses. It is said to have a mechanical strength three times that of ordinary glass and can resist thermal shock. It has been heated to 1300° F. and plunged into ice water with no effect.

The Weber automatic dipping machine has been developed for meat packers and processors that use FM-102 or other meat tenderizer and seasoning solution. The machine, now in use in plants that handle 500 to 16,000 lbs. of meat daily, is distributed nationally by Freezer Laboratories, developers of FM-102. Joseph Greenspan of the firm, and an IFT member, said the machine offers a labor-saving factor which in time pays for itself.

The Du Pont Co. is currently working on the development of the use of **synthetic fibers in paper.** These fibers are a new basic raw material for the paper industry according to the company, and offer properties which may contribute to fold resistance, tear strength, dimensional stability, and resistance to rot and mildew.

The Red-L-Foods Corp., Great Neck, L. I., New York, has recently developed a **folding compartment tray** of rigid aluminum foil. This new dinner tray package requires half the display space of the conventional frozen dinner, fitting into the ice-cube compartment of the home refrigerator. A rectangular wax paper divider separates the two sides when the dinner tray is folded. The tray is produced by Ekco-Alcoa Containers, Inc.



The new Roswell "Compack" preheaters manufactured by Chicago Stainless Equipment Co. are single or twin tube models which are said to incorporate many of the features in the Roswell "Hi-Heet" pasteurizer and "super" preheaters which use saturated steam as a heating medium. The new units utilize hot water as a heating medium. The water is heated automatically through the use of a steam injector. Temperatures are maintained automatically.

PRODUCTS

A **single cellophane** said to be suitable for instore supermarket packaging of fresh and processed meats, produce, poultry and fish has been introduced by the Film Division of Olin Mathieson Chemical Corp. The film, designated as Olin OF-16 Cellophane is said to be non-fogging and permits oxygen to reach the wrapped product. It is designed to cut the inventory problem for the retailer, based on its ability to package the abovementioned variety of products.

Lemon oil, not as a flavor, but as an enhancement to flavor of in-

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Exchange Pure California Lemon Juice

Lemon juice is nature's most effective anti-oxidant. It contains many organic reductants, including ascorbic acid and a rather broad group of phenolic anti-oxidants which fall under the classification of flavonoids, sulphydryl-like compounds and possibly flavonols, which act synergistically to give lemon juice its remarkable anti-oxidant properties. It discourages the growth of microorganisms, retards enzymatic action, prevents oxidative browning, reduces the pH of low acid foods and actually possesses the ability to enhance natural food flavor in many foods such as the natural peach flavor in freestone peaches. It is prepared by Sunkist Growers especially for industry use in baby foods, low acid fruits and vegetables, canned and frozen fruits, fruit juices and nectars, mayonnaise and salad dressings, sea foods in all forms, cured meats and wherever a problem of appearance or perishable flavor exists.

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There is one tailored to your special need. They are used by more American preservers, confectioners, and food processors than all other brands *combined*. Guaranteed by Sunkist.*

Exchange Low Methoxyl Pectin— Pectin L. M.

The *only* pectin that forms a true jell without sugar. It is the exclusive choice for aspics, jellied fruit and vegetable salads, low calorie jams, and dietetic fruit jells. Guaranteed by Sunkist.*

Exchange Pure California Orange Juice

Gives your product more of the true fruit characteristics—because it is made from California oranges, known for their richer content of ascorbic acid, amino acids, polysaccharide complexes, B complex factors, carotene (pro-vitamin A), and aromatic flavor compounds. Prepared especially for the food and beverage industry. Guaranteed by Sunkist.*

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Exchange Lemon Oil, U. S. P.— California Cold Pressed

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EXCHANGE brand citrus products are produced and guaranteed by Sunkist Growers, Inc., representing the world's largest supplies of lemons and rich California oranges.

Every EXCHANGE brand product is made in our own ultramodern plants to the highest standards of purity, quality and uniformity.

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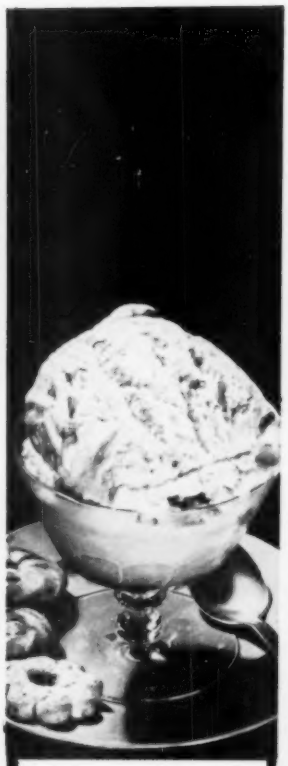

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gredients in baking, has been used recently in a series of tests conducted by Sunkist Growers. According to the reports, lemon oil, added in very small amounts, does not add a lemon taste to the finished product. Instead, it is said to bring out the flavor of the product, such as bread or doughnuts. The research reports also claim that lemon oil contains over 100 identifiable constituents which are said to influence and support flavor.

EXPANSION NEWS

Fritzsche Brothers, Inc., manufacturers and suppliers of essential oils, flavors and aromatic chemicals, has announced the formation of Fritzsche Brothers Argentina, S. A., with offices, plant and manufacturing facilities in Buenos Aires. The operation began around April 1, supplying South American manufacturers with the products similar to those made by the parent firm in the U. S.

The National Cylinder Gas Co. has announced a new name "Chemetron Corporation" subject to approval by its stockholders. The 24-year-old firm's president, Charles J. Haines, revealed that the older name has been outgrown by Chemetron's expansion into chemicals, metals and electronics.

Bausch & Lomb Optical Co., Rochester, N. Y., and Applied Research Laboratories, Glendale, Calif., have announced a consolidation of the two firms. Their diversified product lines will continue to be distributed through the present outlets of each company.

MEMORANDA

An advance notice on the Gordon Research Conferences to be held at Colby Junior College, New London, New Hampshire, indicates that a number of interesting topics are scheduled for the Food and Nutrition sessions, Robert H. Silber, Chairman, and Lester J. Teply, Vice Chairman. The papers and the dates on which they are to be given follow:

11 August

Aline U. Orten. The Intestinal Absorption of Amino Acids

Alfred E. Harper. Amino Acid Balance and Imbalance

James M. Hundley. Vegetable Proteins in Human Nutrition

Theodore Van Itallie. Physiological Aspects of Hunger and Satiety

12 August

Roselyn Alfin-Slater. Further Observations in Fatty Acid Nutrition

Albert Behnke. Changes in Gross Body Composition and in Adipose Tissue As a Result of Caloric Restriction

F. N. Andrews. Hormonal Relationships to Nutrition in Domestic Animals

Franklin C. McLean. Hormonal and Nutritional Factors in Osteoporosis

13 August

R. R. Williams. Food Supplementation in Relation to World Food Shortage

O. L. Kline. Food Supplementation

Olaf Mickelson. Is Toxicology Enough for a Food Protection Program?

Josef Warkany. Nutritional Experiments As an Instrument of Research in Congenital Malformations

Josef Brozek. Recent Developments in Studies of the Relations Between Nutrition and Behavior

14 August

Mark Hegsted. The Establishment of Nutritional Requirements of Man

Calvin Woodruff. Infant Nutritional Requirements: Fact, Fancy and Calculations

Arnold Schaefer. Nutritional Surveys in the Near and the Far East

William J. Darby. The Program in Nutrition of the World Health Organization

15 August

S. H. Wittwer. Effect of Gibberellin on Plant Growth and Composition

Kenneth Beeson. Effects of Fertilizers on the Nutritional Value of Plants

A new, colored motion picture "Essential Oils of Africa" was previewed recently in New York prior to its being offered to institutional, association and educational groups as well as for TV showings. The film was made by Dr. Ernest Guenther, vice-president and technical director of the New York firm. It is a graphic account of his recent six-month survey of Southeastern Africa and its adjacent islands.

The film is said to be fast-moving, colorful and an exciting documentary on life, both flora and fauna, in Africa as well as presenting various aspects of plant cultivation and essential oil production, including that of lemongrass, vetiver, eucalyptus, vanilla, ylang ylang, pepper, clove, citrus, chili and geranium.

It has been reported that Dr. Guenther will be available to speak and show the film at meetings of groups or associations.

Industry-wide production of pressure cans in 1958 will set a new record of half a billion or more units, it was recently predicted by the American Can Co.

It was estimated that the 1958 output should be approximately 19% greater than the previous record of about 420 million cans last year.

Commenting on the rise in production, Robert Hollister, assistant national sales manager in charge of pressure cans, said he expected a sharply increased use of aerosols by the food industry and believes the year may see general introduction of toothpaste and shampoos in pressure cans.

"Future development in the food field is expected to come through the introduction of new pressurized products, such as syrups, spreads, sauces, toppings and similar items," Hollister said.

More Food Processors everywhere are using Morton '999' Salt

Food processors, canners and packers from coast to coast are finding that the quality of Morton '999' Salt is the standard of the food industry. They've discovered that '999' insures better, more uniform flavor in processed foods. And no wonder! Morton '999' is a low-price, premium-grade salt entirely free from bitter calcium and magnesium compounds that can distort flavor.

Morton '999' is always 99.9% clean, pure sodium chloride, exceptionally low in the trace metals copper and iron.

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Morton '999' is the highest purity salt commercially available in all 48 states. '999' quality never varies from shipment to shipment, whether you buy it in bulk for direct salting or brine, or in handy tablets made to your own specifications.

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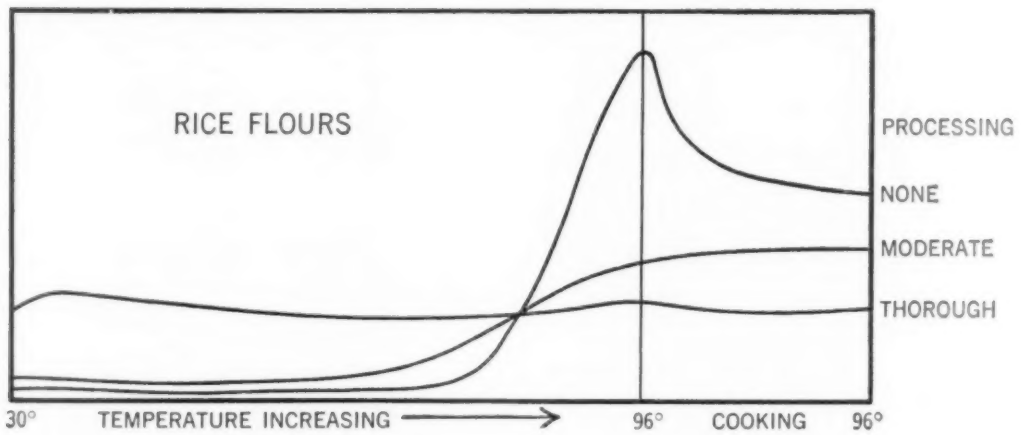

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